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VOICE IN MAN AND IN ANIMALS.[1]

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I.

MAN possesses language, and makes large use of it, while, on the other hand, not even the most intelligent animals have the power of designating objects, or of translating sensations into articulate speech. In this respect the distinction between man and beast is very marked. It has at all times been cited as an evidence of man's exceptional place in Nature. The physiologist, however, discovers an articulate voice in many animals. Some mammals give utterance to vowels and consonants, but the result is only one syllable repeated without variation. Birds, better gifted than the mammals, can sing, and also possess a brief vocabulary: the goldfinch pronounces several words, which it repeats again and again in moments of pleasure. It has a word to express its ill-humor, as also a word for calling attention. In all this we see faint traces of language, notable witnesses of the unity of a phenomenon the gradations of which are wanting.

Some animals live in society, others travel in flocks. In such aggregations there is plainly developed a sort of language adapted for establishing concert of action among the individuals. In building their lodges, how could beavers make a regular division of labor, and so perfectly coördinate their work, if they were unable to understand one another? The marmot, acting as a sentinel, could not warn its fellows of the approach of danger, if it did not possess the power of giving a signal, the meaning of which they understood. When swallows are about to migrate, some of them appear to be concerned about the performance of the periodical voyage some time before the rest: they flock together and utter their call; they flit hither and

[1] Translated from the French by J. Fitzgerald, A. M.

thither to summon individuals who, in their folly, take no note of the change of temperature. Is it not plain that these birds know how to say, "It is time to be gone?"

But in all probability the language of animals gives expression only to very simple impressions and ideas. But, inasmuch as we do not understand it, we cannot define either its extent or its true character. Some persons have the power of imitating the calls and songs of birds; and birds, in turn, repeat human language, without, however, understanding its sense; it is only very rarely that we can recognize in the phrase uttered by the inhabitant of a cage the expression of a desire. Man and dog, close friends though they are, understand one another only by means of a sort of pantomime. Eventually the dog understands some of the words spoken by his master, and the man understands some of the vocal expressions of his trusty friend; and this is the highest result of long association. It appears as though, by a supreme will, an insurmountable obstacle had been opposed to all close communication between man and animals.

Apparently those animals whose organization comes nearest to that of man lack both the faculty of producing an *ensemble* of articulate sounds and the degree of intelligence requisite for attaching to words a strictly determinate meaning. No monkey has ever learned to talk. In our own day the comparative study of specialties of organization and of the life-conditions of living beings has thrown light upon the subject of articulate speech. We may confidently affirm that a creature possessing an instrument or an organ subject to the control of its will comes into the world possessed of an instinct to employ that organ or instrument; guided by intelligence, it will make more or less happy use of it. As individuals differ from one another in the perfection of their vocal organs, so too they differ in the measure of their control of those organs. Natural gifts and judicious exercise afford immense advantages. All men possess a vocal apparatus: for talking or for singing they usually employ it skillfully enough to answer all common demands; while a privileged few produce wonderful effects with the same instrumentalities.

The mechanism of voice deserves to be studied by all. As regards man, we now have very accurate knowledge of the manner in which speech and singing are produced. Means having been found of viewing the play of the different parts of the larynx, physicians intent upon the advancement of the art of healing, physiologists spurred on by the desire of explaining phenomena, singers eager to penetrate the secret of the highest achievements in their art, have all devoted themselves to patient researches. The results of a multitude of investigations have been published, and in this way science has been greatly extended. Dr. Mandl, an observer who had already studied in its minutest details the structure of the respiratory organs, has given the fullest account yet presented of the vocal apparatus in all the phases

of its activity.[1] At present he is engaged in studying the phenomena of voice in the larger animals. As for birds, it is to be hoped that soon we shall understand the organic peculiarities in virtue of which they are able to talk or to sing. Doubtless before long we shall discover the relations subsisting between life-conditions, physical powers, and psychological faculties.

In all those communities which have attained a high degree of intellectual culture, the explanation of natural phenomena has ever more or less engaged the attention of the best minds. Among the ancients we observe a manful effort to discover the secret of the human organization. The origin of speech and of song was unquestionably a subject of profound inquiry for them. Galen, the last and the most famous of the ancient physicians, wrote a description of the larynx, and this description is the work of a master who recognizes the high importance of the work he is engaged in. Since the time of the Renaissance anatomists have been studying the minutest details, and physiologists experimenting. Thus everything was ready for new discoveries, so soon as it should be possible to place before the eye the performance of the instrument used by the singer. It would be difficult, without some knowledge of the vocal apparatus, to understand how the sounds are produced, and hence we will briefly describe those portions of the respiratory organs in which the voice is formed.

The trachea, which is the passage for air between the ~~mouth~~ pharynx and the lungs, ascends from the chest to the middle region of the neck; it is made up of cartilaginous rings. At its lower extremity it branches out into two tubes, which are divided and subdivided into numerous ramifications: these are the bronchi, which terminate in the lung-cells. At the upper extremity of the trachea is the larynx, appearing like an angular box, and crowning the trachea like the capital on a column. Cartilages connected by ligaments give considerable strength to the walls of the larynx. Internally these walls have a lining of mucous membrane, which forms folds known as the vocal cords, or better, lips. Under the action of special muscles these folds separate from one another, are elongated or shortened, or become tense, and hence the differences of sound. The cartilages are four in number: two on the anterior surface of the box and two on the sides. In advanced age these cartilaginous plates ossify; the suppleness of the larynx is then greatly diminished, and the voice loses the power of modulation which it possessed in the period of youth. One of the cartilages, which has the form of a ring, is much higher behind than in front. This ring, being firmly fixed upon the first ring of the trachea, serves to support the various parts which constitute the larynx. The largest of these parts shields, as it were, the front of the vocal apparatus: it consists of a plate of cartilage bent into a V-shape, with the point of

[1] "Traité du Larynx et du Pharynx," 1872; "Hygiène de la Voix parlée et chantée," 1876.

the V turned forward. In women it is less prominent than in men, and it is known as Adam's apple. The lateral cartilages, which spring from the ring-cartilage at the back of the larynx, assume the form of little triangular pyramids with uneven surface. They are slightly curved toward the upper extremity, and support a little horny plate, which in the eyes of the ancient anatomists resembled the snout of a pitcher.[1] The lateral cartilages, being very mobile, play an important part in the emission of the voice.

The larynx is to some extent movable. Being attached to the hyoid or tongue bone by means of a membrane strengthened by ligaments, it is lifted up by the action of muscles extending from the tongue-bone to the external surface of the thyroid cartilage; it is pulled down by the action of muscles which extend from this same cartilage to the sternum. Further, the vocal apparatus is affected by the movements of the pharynx and of the tongue, as also by the respiratory movements. The solid parts of the larynx, being more or less movable, change position under the action of musoles which pass from one to another of them. Bundles of muscular fibre which spring from the annular cartilage (the cricoid) cause the thyroid cartilage to move up and down, and this movement produces tension of the vocal cords. Muscles springing from the cricoid and from the thyroid produce a rotation of the lateral cartilages, and modify the conditions of the cords. Finally, there are bundles of muscular fibre extending from one lateral cartilage to the other; when these contract, the walls of the larynx are brought nearer to each other, and the opening through which the air passes is made narrower.

Internally, the larynx is lined with mucous membrane, which is continuous with the mucous membrane of the mouth. Two pairs of ligaments, extending from the thyroid to the arytenoid, divide the cavity into compartments. The lower portion is limited by an arch formed of thick folds of mucous membrane. The middle portion is distinguished by the presence of folds supported by ligaments. These are the vocal cords, which play the principal part in the act of phonation. The superior cords, which resemble thin bands, occupy both sides. The inferior cords, or true vocal cords, which are very thick, are situated beneath the upper, and extend considerably beyond them toward the median line.[2] They bound the orifice called the glottis. This orifice, which in the state of repose is triangular in shape, varies constantly in form and in dimensions under the influence of respiration and the emission of the voice. This use of the term glottis, which signifies *tongue*, to designate an orifice, is very curious, and is

[1] The ring-cartilage is the *cricoid* cartilage of the anatomists; the V-shaped cartilage is the *thyroid;* the lateral cartilages are the right and left *arytenoids;* and the little plate they bear, the *cartilages of Santorini.*

[2] On each side, between the superior and inferior vocal cords, occurs a large cavity. These cavities are known as Morgagni's ventricles.

the result of a strange confusion of ideas. The ancients observed in the larynx "organs resembling the mouth-pieces of ancient flutes, viz., the parts on the right and left, which meet and regulate the passage of the air." Later, the term denoting the folds which bound the orifice was used to designate the orifice itself. This error has been confirmed by the usage of centuries, but yet it is better to give, as Mandl does, to the space between the vocal lips, the name of glottic orifice, or orifice of the glottis. The superior portion of the larynx is the vestibule communicating directly with the back part of the mouth. Above the entrance to the vestibule and back of the tongue, a fibro-cartilaginous plate, the epiglottis, defends the passage. Under ordinary circumstances, the epiglottis stands vertical, presenting no obstacle to the free passage of air in both directions. When depressed, it covers the opening. Every one, from personal experience, is familiar with the painful sensation produced by the entrance of liquids or solids into the respiratory passages. Apparently the epiglottis closes up this passage during the act of swallowing, but on this point we have no certainty; we cannot observe the act of deglutition, and we know that the vocal cords may be moistened by liquids without causing inconvenience.

Like every other organ, the larynx presents considerable individual differences. A good development of the larynx indicates a strong, deep voice. In childhood this apparatus undergoes very little change, but at the period of adolescence it grows very rapidly, the effect being an alteration of the voice, very notable in boys, but inconsiderable in girls. In all cases, without regard to stature, the larynx is smaller in women than in men. Its angles are less salient, its muscles weaker, its cartilages thinner, and more supple: the sharp notes of the instrument are the evidences of these peculiarities of conformation. Though our general knowledge of the vocal organs is very positive, nevertheless we are unable to determine the characters of the voice by simply examining the larynx, for it is impossible to compare in all their details those instruments whose good or bad qualities are known.

The vocal apparatus is perfected by the addition of the cavities which produce resonance, viz., the pharynx, the mouth, and the nasal fossæ. The pharyngeal cavity, into which open the œsophagus and the larynx, is continuous with the buccal cavity, a hollow box admirably adapted for articulation. Its shape and size are extremely variable. The cheeks constitute walls which can be compressed or dilated with the slightest effort; the lips, which bound the anterior opening, are perfectly mobile; the tongue can be moved in every direction; in the rear, the velum palati, or soft palate, suspended from the palatal arch, is supple and contractile. This veil of the palate is simply a fold of mucous membrane, separating the buccal from the pharyngeal cavity; it also extends to the nasal fossæ, which it closes; it terminates

in an appendage called the uvula. When the velum palati, or soft palate, does not discharge its functions properly, the voice assumes a specially disagreeable character—it becomes nasal. The two rows of teeth act a part in producing speech; a breach once made in this rampart, the pronunciation becomes defective, the air escapes through the unguarded space, and the result is a hissing sound.

The plan of action of the whole vocal apparatus being under investigation, in the absence of the means of direct observation, recourse has been had to endless stratagems, in order to have a glimpse of the play of the organs and to explain the mechanism of voice-production. It has been a struggle with incredible difficulties, in which the human mind, though it has not won a complete victory, has nevertheless acquitted itself with honor. Some of the investigators succeeded in forming theories which are not very far from the truth, but these theories are now only the monuments of a period whose science is antiquated.

Galen, in comparing the organ of voice to a flute with double mouth-piece, referred the production of the sound to the vocal cords. Fabrizio d'Acquapendente, the famous professor of the University of Padua, held that the dilatation and contraction of the glottic orifice determined whether sounds shall be grave or acute. Dodart, a member of the old Académie des Sciences, held that the tone depends upon the greater or less number of vibrations of the vocal cords. Ferrein, one of the famous anatomists of the eighteenth century, conceived the idea of causing the larynx of a dead body to produce sounds by blowing through the trachea. He affirms that the lips of the glottis vibrate and emit sound like the strings of a violin. Magendie made experiments upon living animals; having laid bare the glottis, he saw the vocal cords vibrating when the animal uttered a cry. Savart, famed for his researches in acoustics, compared man's vocal apparatus to an organ-pipe. Lehfeld, a German author, laid stress upon the special effects of the cords, as vibrating through their entire substance, or only at their free edges. Cagniard de Latour constructed artificial larynges with mouth-pieces of membrane. John Müller, the physiologist, after a series of diversified researches, was of the opinion that "the vocal organ is a mouth-piece consisting of two lips, and that the vibrations of these is the chief cause of the sound—the pitch being determined by the width and length of the orifice of the glottis." Longet, who made numerous experiments on the actions of the muscles of the vocal organ, threw new light upon the conditions modifying the vibrations. In short, the result of all these researches, made by investigators who never had seen the larynx of a living man, was firmly to establish one point, namely, that the voice is formed in the glottis. The proofs of this are conclusive, for, if an opening be made in the trachea, the voice ceases; it reappears when we close the opening again; it persists though the superior parts

of the larynx be rent and torn; but it is destroyed by lesion of the nerves of the little muscles which alter the form of the glottis and stretch the vocal cords.

But alongside of these undisputed facts there were a number of undecided questions which stimulated to further research. Some investigators were continually meditating on methods of viewing the larynx in normal action. Toward the close of the last century mirrors were first employed for this purpose, but the earliest attempts were unsuccessful. For fifty years all efforts of this kind proved abortive, and the thought of examining the interior of a living larynx was coming to be regarded as an illusion. Suddenly, as by an inspiration, the solution of the problem occurred to the mind of Manuel Garcia. Ignorant of the labors of others who had endeavored to obtain a view of the vocal apparatus, Garcia conceived the idea of observing his own vocal organs in the act of singing. Taking a small mirror attached to the end of a long rod, he placed it beneath the uvula, and then, illuminating with a beam of sunlight another mirror which he held in his hand, he had a full view of his own larynx. Thus was discovered the true method of investigation. In 1855 Garcia communicated to the London Royal Society the result of his observations on the living larynx.[1]

When a new mode of research is discovered, the first investigators to take hold of it are those who have little or no prepossessions of their own. They perceive that, by varying the application of the process, notable results may be attained without much labor or ability. Garcia's process called forth on many sides much enthusiastic zeal. This was the case especially at Vienna, but the results fell short of the anticipations. The caprices of the sun's light and the defects of artificial light were such as to discourage the observers. In order to succeed, the means of illumination had to be improved at any cost. Garcia had used for a reflector a plane mirror; J. Czermak, Professor of Physiology at Pesth, finding his pattern in the instrument used for inspecting the eye, the ophthalmoscope, employed a concave mirror, which concentrates the light. The feasibility of studying man's vocal apparatus by means of the laryngoscope was now insured. Still, for a long time afterward, experimenters busied themselves with devising contrivances for increasing the intensity of the light by combinations of glass lenses.[2]

Czermak, who by long practice had acquired great skill in the manipulation of his own larynx, visited the principal cities of Germany, taking with him a good instrument. His demonstrations were

[1] "Observations on the Human Voice," "Proceedings of the Royal Society of London," vol. vii.

[2] The different kinds of instruments are described in Mandl's work, "Traité du Larynx;" also, in the article, "Laryngoscope," by Dr. Krishaber, in "Dictionnaire Encyclopédique des Sciences Médicales."

witnessed with profound interest by physicians and physiologists. In 1860 he came to Paris, and astonished many of the members of our learned societies. He exhibited not only the whole of his own larynx, but also the interior of his trachea down to the bifurcation—a sight well calculated to cause astonishment when one sees it for the first time. The vocal organ cannot be examined with the same facility in all persons, and some practice is needed for experimenting successfully. Dr. Mandl and Dr. Krishaber possess an extraordinary power of controlling the various movements of the larynx. After repeated experiments we now fully understand the functions of the vocal organs in speaking and in singing. The studies of Helmholtz upon the formation of sounds have thrown new light upon the phenomena of voice.

The notes of an organ, when heard beneath the arched roof of a cathedral, produce a profound impression. Inasmuch as no other kind of music so closely resembles the human voice, we can fancy ourselves communing with the thoughts and feelings of the human soul. We naturally compare the organ to man's vocal apparatus. The organ has a bellows, we have lungs; in the organ is a "sound-board," the trachea performs the same function; the vibrating tongue of the organ has its counterpart in our vocal cords; and the pharynx and the mouth answer to the resonating cavities of the organ. Yet the natural instrument is immensely superior to the artificial one. In the organ there must be a number of pipes to produce the different sounds; in the natural instrument there is only one pipe for both speech and song, but it is a wonderful pipe, being susceptible of endless modifications. It has a double vibrating spring and a resonator. The glottis is the vibrating spring or tongue, and, according as the air-passage is more or less narrowed, and the vocal cords more or less tense and vibrant, the sounds emitted are either grave or sharp. The mouth forms the resonator; the cavity of the mouth is susceptible of almost endless modifications, producing an infinite diversity of sounds.

Our various senses are each affected by a special order of impressions; the organ of hearing takes note of sounds, which are propagated by concussions of the air, by vibrations. When these vibrations are continuous, regular, isochronous, they constitute a musical sound; when irregular, the result is noise. Sounds possess very definite characters, as intensity, pitch, timbre. Intensity depends upon the amplitude of the vibrations, which travel in the form of concentric spheres from the starting-point, as the waves caused by a pebble dropped into water are diffused in the form of concentric circles. Amplitude is always the result of the force of the primary shock. The pitch of a sound is determined by the number of vibrations occurring in the space of one second: when the vibrations are few, the sound is grave; when very numerous, it is sharp. In a word, the shorter the duration of each vibration, the higher the pitch of the sound. Timbre means quality of voice. We distinguish voices

by their timbre; we hear some one speaking, and recognize who it is without seeing him; or we hear a strain of music, with several sounds of the same pitch, but we readily by the timbre distinguish from one another the violin, the flute, the clarionet. The differences are the result of the different forms of the vibrations; this may be demonstrated by experiment. Whether we consider the movements of a pendulum or of a tuning-fork, in every case the vibration, when traced automatically, gives a characteristic line for each variety of timbre. If by means of the ear, rendered highly sensitive by long practice, we study to distinguish the different forms of the waves, we recognize in addition to the fundamental sound other higher sounds, the harmonics. Helmholtz's resonators aid the analysis by the ear. The resonator is a little hollow sphere with two open tubes, one of them conical, so as to fit into the auditory passage. The fundamental sound, which is much deeper than the other sounds, is thus considerably reënforced. In like manner, with the aid of proper resonators, it is easy to hear the harmonics of the human voice. Helmholtz ascribes the diversity of timbres to the intensity of the harmonics. Physiologists hold that there exist other causes, as yet not ascertainable.

In the state of rest, when respiration is performed without effort and with regularity, the vocal cords are almost motionless; during the alternations of inspiration and expiration, the orifice of the glottis does not alter its form. After a cry has been uttered, there occurs a deep inspiration, and then the vocal cords diverge, widening the aperture. When expiration is suspended or performed slowly, the orifice closes more or less. At the moment of emitting a sound, the lateral cartilages of the larynx are brought near to one another, and the vocal cords are suddenly made tense and applied closely to each other in their anterior portion, or even throughout their entire length; the passage of air is thus intercepted. Instantly the orifice opens again, and the air in passing between the vibrating vocal cords is itself thrown into vibrations, and sound is the result. These operations are performed gently or forcibly according to circumstances. Here we have the "glottic sound," as it is called by Mandl; isolated, it is inaudible, but it reaches our ear only after it has traversed the pharynx and the mouth; the vibrations of the air modify it. Every one has remarked the change produced in sounds by their passing through a tube or the like; for instance, when we hear a voice coming from the bottom of a well. Hence the voice is formed by the combination of the sounds of the glottis and of the cavities lying above the larynx: when these cavities are passive, the voice is inarticulate; when they undergo certain changes of form, the voice becomes articulate.

The pharynx and the mouth, which serve as a resonating box, produce sounds whenever the air they contain is made to vibrate by the

current from the lungs or from any other source. That this is the case is shown by certain decisive and very interesting experiments. On opening the mouth and adjusting the lips for the pronunciation of a given vowel (though without uttering the slightest sound), the vowel may be rendered sonorous by placing in front of the mouth a vibrating tuning-fork. This method was first applied by Helmholtz. The same result may be obtained by bringing in front of the open mouth, through a tube with narrow terminal orifice, a current of air from a pair of bellows. This plan originated with M. König. Thus it is seen that the various sounds known as vowels depend simply on the form of the resonating cavities, the pharynx and the mouth.[1] When these cavities alone are in action, the voice is aphonic, whispering; it is sonorous when the vocal cords vibrate. For a long time it was held by physiologists that vowels pronounced even in a whisper come from the glottis; precise information concerning these phenomena is of very recent date.

The number of vowels is generally restricted to five, six, or seven; these may be regarded as natural types, being found in nearly all languages. But, in addition to them, there are intermediate vowels, and a multitude of vowel combinations, so great is the power of modification possessed by the buccal cavity. Then there are nasal intonations (very abundant in the French language) produced by depressing the velum palati. A language might consist only of vowels, says Max Müller, and indeed this is very nearly the case with some of the Polynesian dialects.

Most languages possess aspirates of more or less harshness. In French they are very few and weak, but in German they are frequent and strong, while in Arabic they are specially forcible. Aspiration requires the action of the glottis; the orifice is reduced for an instant, and the air, arrested by this obstacle, in issuing through the narrow slit, produces a sound of something brushing against the vocal cords. The aspirate is sometimes sonorous in the Semitic languages.[2] The guttural sounds of the Arabs used to be the subject of grave discussions among linguists, but Czermak put an end to these controversies. That learned physiologist, having fallen in with an Arab, availed himself of the opportunity to examine with the laryngoscope an organ capable of producing a sonorous aspirate. The whole matter was now plain: it was found that, while the epiglottis was depressed, the vocal cords were in close contact; the orifice being thus absolutely closed, the current of air driven against the roof produces a vibration beneath the glottis, in the fissure of the larynx.

The sounds produced in the buccal cavity are broken up on meet-

[1] When we pronounce the vowels *a*, *e*, *i* (pronounced *ah*, *eh*, *ee*), the vertical diameter of the pharyngo-buccal cavity is diminished, while its transverse diameter is increased; it is exactly the contrary with the vowels *o*, *ou*, and *u* (pronounced *oh*, *oo*, *ü*).

[2] It is the *aïn* of the Arabic.

ing obstacles; thus are formed the sounds known as consonants. In setting up these obstacles, the tongue, the teeth, the lips, the soft palate, play respectively a more or less important part. We readily distinguish the labials, the linguals, the dentals, the nasals. No classification, however, will stand a rigid analysis; the simultaneous play of the teeth, tongue, lips, and soft palate, and the somewhat doubtful character of some sounds, render all classifications more or less arbitrary.

Among the consonants are the sounds of puffing, hissing, trilling, and these are pronounced without the aid of vowels.[1] The labials are formed mainly by the movement of the lips—the easiest movement of all those concerned in the utterance of speech. Accordingly as the lips are closed tightly or loosely, two distinct letters are pronounced; if the closure is imperfect, a third letter is produced.[2] There are two letters, *m* and *n*, which it is impossible to pronounce with the soft palate depressed, so as to close the nasal passages. Czermak introduced water into his nostrils, and then tried to pronounce these two consonants; the water was forced out by the passage of the air. The sound of the dentals is produced by a strong pressure of the tongue usually against the teeth, which, however, are not indispensable. The gutturals are pronounced by bringing the tongue back against the palate.

All these consonants may be classed, according to the character of the sound, as either *surds* or *explosives*. When the external air remains in communication with the air expired, notwithstanding the obstacle set up for articulation, the consonant may be sustained during the continuance of the expiration.[3] Where there is no communication, the duration of the sound is restricted to the instant in which the obstacle is removed, and the result is a slight explosion of the air.[4] This is shown conclusively when we precede a consonant with a vowel, and the same experiment serves clearly to show the distinction between hard and soft explosives.[5] In pronouncing the former the glottic orifice is narrow, the current of air is feeble, and the sound persists for a moment after the mouth has opened; in the other case, the glottis allows the passage of a stronger current of air, and the sound has no perceptible duration.

Certain consonants are in English called trills;[6] they are produced by the interruption of the breath at regular intervals, by vibrations of the soft palate and the extremity of the tongue. In the soft trill, the edges of the tongue produce simple oscillations of the air, but in the harsh trill, the vibrations produced at once by the palate and the tip of the tongue become intense. Finally, there are certain sounds of frequent occurrence in English, German, and the Slavonic languages; these are produced by an expiration differing from one

[1] *f*, *s*, *r*. [2] *b*, *p*, *v*. [3] *z*, *zh*, *v*, *s*. [4] *b*, *p*, *d*, *t*, *g* (hard), *k*, *x*.
[5] *b*, *d*, *gh*, as contrasted with *p*, *t*, *k*. [6] *l* and *r*.

another according to the obstacles opposed by the tongue, the teeth, and the lips.[1]

It has been demonstrated that the sounds of speech are formed in the buccal cavity, by processes which vary within very narrow limits. Authors who have studied in their own persons the pronunciation of the vowels and consonants describe with great minuteness the positions assumed by the lips, the tongue, the soft palate, under all circumstances, and give drawings which show the various operations we perform while articulating letters and syllables.[2] These observations possess great interest; but yet the rules thence derived are not so rigorously true as to be indisputable. As Mandl observes, sounds that are nearly identical are produced with different positions of the organs of speech. If a person has lost all his teeth, he modifies the play of the lips and tongue, and so contrives to speak intelligibly. The voices of persons we know can be imitated so that the deception shall be perfect. By changing the timbre, the voice is made to sound as though it came from a cavern; this is the ventriloquist's art. Persons who had had the misfortune to lose a considerable portion of their tongue, have been able to converse, though it is not affirmed that hearing them speak would be a pleasure. Some birds find it possible to utter sounds which with us require the use of the lips. In a word, there is nothing absolute in the acts which produce speech, though in general the same organs do not differ very much in their mode of procuring the same results, as may be shown from the fact that congenital deaf-mutes who have learned to speak interpret the movements of the mouth with infallible certainty; they see the speech of the interlocutor. This proves that our modes of articulation present only shades of difference.

The phenomenon of deaf-mutes capable of speech has long been esteemed a marvel. In the middle ages there was one instance of this, the credit of which is due to the patience and skill of Beverley, Archbishop of York. In the sixteenth century, the universal scholar, Jerome Cardan, discussed the possibility of teaching the use of the voice to congenital mutes. About the same period, the Spanish monk Pedro de Ponce was, according to an epitaph, famous throughout the whole world for his power of causing mutes to speak. He had for his pupils two brothers and one sister of Pedro de Velasco, and the son of Gaspar de Guerra, Governor of Aragon. Some time later, Juan Pablo Bonet, in a work which is the oldest known upon this subject, treated of the art of giving speech to the dumb.[3] In

[1] *sh* and *th* in English; *sch* in German; *tch* in Russian.

[2] *See* Ernst Brücke, "Grundzüge der Physiologie und Systematik der Sprachlaute für Linguisten und Taubstummenlehrer," Vienna, 1856; Max Müller, "Lectures on the Science of Language;" Johann Czermak, "Populäre physiologische Vorträge," Vienna, 1869, etc.

[3] "Abecedario demonstrativo: Reduccion de las letras y arte para enseñar a hablar los Mudos," 1620.

England, Holland, and Germany, this art was reduced to practice with more or less favorable results; instances of success were few and far between. About the year 1732, a young Israelite, who had come to France from Estremadura, being touched by the unhappy lot of a woman whom he loved, resolved to devote himself to the instruction of deaf-mutes. His name was Jacob Rodrigues Pereira. At La Rochelle, a boy thirteen years of age was brought to him; soon the lad was able to speak, so as to astonish all. The result was noised through the city; one of the *grands fermiers* had a deaf-mute son, whom Pereira undertook to instruct. After sixteen months of study, he presented his pupil to the Académie des Sciences. The assembly was delighted. Several of the members undertook to examine the case thoroughly, and on July 9, 1749, Buffon reported that the lad had answered questions "both in writing and by word of mouth." At the court of Louis XV. this marvel excited general admiration. The Duke de Chaulnes had a godson that was deaf, a boy of about twelve years; him he placed under the care of Pereira. This pupil, Saboureux de Fontenay, who in after-times attained to some celebrity, was very intelligent, and quickly improved under instruction. On being exhibited at the Académie des Sciences, and there tested in various exercises, he occasioned no little surprise. The official report concludes by stating that "M. Pereira possesses a singular gift of teaching congenital mutes to speak and read."

Pensioned by the king, and honored with marks of esteem by illustrious personages, Pereira continued his labors. He gave the power of speech to a large number of mutes, but he kept his method of education secret. The memory of this brilliant success had been wellnigh effaced, when the Abbé de l'Épée won the favor of all classes of society by giving to the deaf a sign-language. Pereira left behind him pupils who justly believed that they did honor to their master by making public the secret of their instruction; some of these scattered notes have been collected. It has required only a little research to discover the forgotten method.[1] The teaching of deaf-mutes to speak was again brought into practice, and at Geneva M. Magnat was very successful in carrying out this system. He visited Paris, accompanied by some of his pupils, who, though utterly deaf, conversed with wonderful ease. Some grandsons and great-grandsons of Jacob Rodrigues Pereira, on witnessing the renewal of the wonders performed by their ancestor, founded at Paris an institution for educating mutes. In this establishment, children of various ages, about thirty in number, afford matter for curious observations upon the phenomenon of voice and the articulation of language.[2]

[1] *See* an interesting sketch by M. Félix Hément, entitled "Jacob Rodrigues Pereire, premier instituteur des sourds-muets en France," 1875.

[2] The institution founded by the Messrs. Pereire, at 94 Avenue Villars, Paris, is directed by M. Magnat, author of the "Cours d'articulation, pour l'enseignement de la parole articulée aux sourds-muets," 1874.

A person who is deaf from birth is also absolutely dumb, until he is trained to the use of speech; he utters no cry. His lips and tongue are motionless; his mouth remains shut, his larynx is in a state of unbroken repose; he breathes only through the nostrils. When first the effort is made to have him pronounce a letter written on the blackboard, it appears to be simply impossible for him to produce any sound. The instructor shows the young mute how to open the mouth, and how to hold the tongue and the lips. He places the child's hand upon his own larynx, so that it may feel the movement necessary to be performed. In the beginning, the simple expulsion of the breath is difficult, but, after repeated exercise, there is a sort of stifled articulation; later, with some difficulty, a clear sound is obtained. In this way the deaf-mute learns to pronounce all the vowels and consonants. It needs but a short time to acquire the pronunciation of the labials. Longer practice is needed in order to learn the play of the tongue, and the proper mode of emitting the breath in articulating those consonants which call for only a slight intervention of the lips. Having learned the alphabet, the mute begins to pronounce syllables and phrases written on the blackboard. Finally, he speaks, and is understood. He writes from dictation, with his eyes fixed upon the person who addresses him questions, and makes his answers confidently.

OUR COMMON MOULDS.

By BYRON D. HALSTEAD

THE following remarks are from personal observations which have been made from time to time as circumstances would permit. For convenience, the term *mould* will be extended beyond its narrow technical meaning, and include all those forms of vegetable life which are usually designated by that name. No lengthy argument is needed to prove that mould is of common occurrence. It is a fact well known to every person, from the wholesale provision-dealer down to the hungry child who eats his crust upon the street.

Where these plants do not grow it is difficult to say; but to point out the favorable conditions for their growth and some of the forms which they there assume is an easier task, and to this part of the subject the reader's attention is invited.

Moulds belong to that peculiar parasitic group of plants called *Fungi*, the members of which never have anything like green leaves, the workshops of higher plants, and are therefore unable to build up their tissue from unorganized matter. They must feed upon that which is already organized, either animal or vegetable, living or dead, as the species will decide.

One of the most essential conditions for the development of these minute fungi is the presence of a good degree of moisture. So well known is this, that to many minds *moisture* and *mould* bear to each other nothing less than the relation of cause and effect. A warm atmosphere is also required. In winter the housewife exercises fewer precautions to keep these intruders from her viands than during the warm summer weather. Besides organic matter, moisture, and warmth, a free access of oxygen must be added as an essential condition for the perfect development of moulds.

When the season comes and the soil is ready, the farmer knows he must sow the seed, or he cannot hope to reap a harvest. So it is with the moulds: to the conditions for growth there must be added the germs of life, or no mould will be produced. How this sowing is accomplished will be better seen after some of the species are considered more in detail.

Our common bread is a substance which offers special inducements for the growth of various moulds, and, in order to study them, a slice was taken and placed on a zinc rack on a dinner-plate and covered with a glass bell-jar lined with filtering-paper which dipped into some water in the bottom of the plate, producing thus a moist atmosphere by the evaporation from its extensive surface. This culture

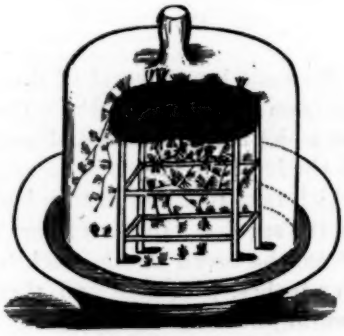


FIG. 1.—MOULD CULTURE.

(Fig. 1), placed in a warm room, secured all the important conditions for the production of a crop of mould. On the bread thus situated a mould made its appearance in about thirty-six hours, and proved to be one of the most common of the bread-moulds (*Mucor stolonifer*), shown in Fig. 2. When first noticeable, the surface of the bread is covered with a cobweb-like mass of fine white threads, called *mycelium*, which run in all directions through the tissue of the bread, and perform the work of absorbing nourishment. Soon other and larger threads begin to rise into the air, their tips enlarge, the protoplasmic contents of the threads passing up into the ends, which finally assume a spherical shape. At first these large round heads are of a white

color; but soon they begin to grow darker, their contents shaping into little round bodies, which when ripe are dark-colored and fill the capsule to repletion. These little bodies thus produced in vast numbers in the swollen ends of these vertical threads are termed *spores*, and answer the same purpose for moulds that seeds do for flow-

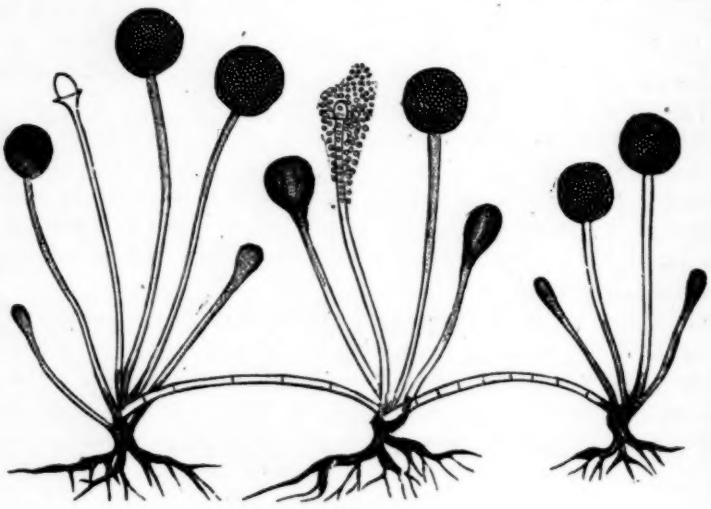


FIG. 2.

ering plants. From the same base several of these capsules are produced, varying in age from threads with their tips little swollen, to the tall and aged ones which have ripened and scattered their spores. This mould has much the habit of the strawberry-plant, throwing out runners or stolons, which take root and in turn become new plants to increase and continue the species. In the culture we have often seen this mould hanging from the bread on the rack to the plate below, a distance of four or five inches, with here and there the stolons with their fruit-clusters hanging in mid-air (Fig. 1).

The fruiting which has been described is asexual, and the spores thus formed can be likened to the bulbs in the axils of the leaves of the tiger-lily and other reproductive bodies in flowering plants which do not result from a fertilized ovule. Several trials were made to cultivate the sexual fruit of this plant, but without success; another member of the same genus (*Mucor Syzygites*), which grows on decaying toadstools, produced them under the bell-jar in large quantities. When this plant reaches the proper stage of development for the formation of its sexual fruit, the tips of various filaments become noticeably swollen. Two of such enlarged ends grow toward each other and finally meet by their extremities, or rather by the blending of the processes which each cell puts out, thus forming at first a small cell between the two united filaments. As maturity is reached, this *zygaspore* ac-

quires a diameter much greater than that of the filaments which have produced it, and is many hundred times the size of the spores formed in the capsules. It is also provided with two coats, the outer one thick, dark-colored, and covered with warty excrescences, except on the two ends where the remnants of the conjugated filaments remain. Successive stages in the development of these spores are shown in Fig. 3. At *a* the two swollen threads are near each other; *b*, the process partly completed, with the middle cell plainly seen; and *c*, the full-formed zygaspore, with the remains of the old cells. The importance of these sexual spores in the economy of the plant is not difficult to

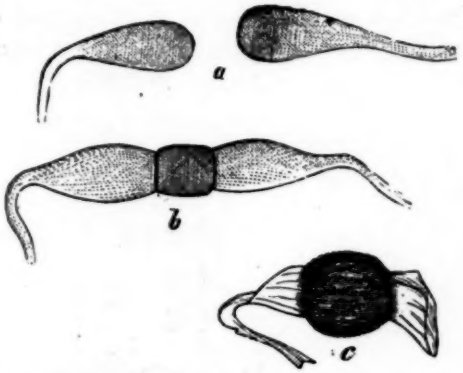


FIG. 3.—ZYGOSPORES OF MUCOR STYLOSITES. De Bary.

understand. The minute asexual spores have a very thin covering, and under favorable conditions will germinate as soon as formed, but on the other hand are readily destroyed by extreme climatic changes. The large, well-protected zygaspores which germinate only after months of ripening, are in every way fitted to carry the species through the unpropitious season of winter, times of drought, and severe exposure. When the zygaspore germinates it produces very soon a large crop of capsules, and their little spores are scattered far and wide ready to develop into plants in a few hours, as circumstances shall decide. This dual form of fruiting is an interesting feature in the life of these little plants, and is as effectual in preserving the species as it is interesting.

After upward of a week from the time the *Mucor*, of which we have been speaking, made its appearance on the bread, another mould was noticed growing over its surface, which was of a much finer structure and dingy yellow in color. When placed under the microscope, it was found to be peculiar, both in structure and habit of growth. The filament which bears the spores, as it rises from the matted surface of the *Mucor*, divides into two branches, each of these into two others, and so on, until ten or more branches are reached. The same angle of divergence being preserved in all the branching, the com-

pound top assumes a very regular, semicircular outline, as shown in Fig. 4, *a*, where the filaments are represented by single lines; the whole of the branch *b* is a more highly-magnified view of a dark tip at the end of one of the branches in *a*; and at *c* is shown, on a still higher scale, one of the ultimate branches in *b*, with the spores arranged in rows of four around the enlarged end; while *d* is one of those tips after the spores have fallen away.

The reader will please bear in mind that this figure, and all the others, with the single exception of the first one, represent the object as greatly enlarged—the microscope used for most of the work magnifying 650 diameters. An entire plant of the one in question (*Piptocephalis Fresæniana*) is scarcely visible to the naked eye when prepared on a glass slide for investigation with the microscope.

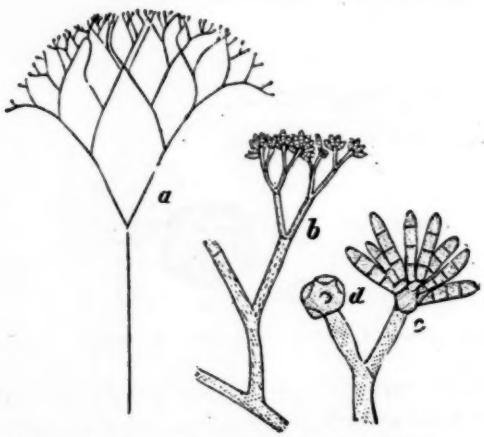


FIG. 4.—PIPTOCEPHALIS FRESÆNIANA. De Bary.

That which makes this mould of particular interest is the fact that it is a parasite, and cannot live unless it has some other mould upon which to grow. This easily explains why it does not make its appearance until the *Mucor* is well established. Here we have a true parasite growing on a saprophyte; or one mould which steals its substance from another which derives its living from the bread. We will not stop to reason upon the matter, or wonder how this strange state of things came about, but will leave the fact as it exists to those who would know the cause of all things both great and small.

There were two or three other members of the *Mucor* genus which grew on various cultures, but, as they differ only in minor points of structure from the one treated, space will not permit of their being further mentioned.

The bones of a recently-killed dog proved to be very well adapted for the growth of the largest-known species of mould. Those who have a passion for scientific names may call it *Phycomyces nitens*. It

is one of the few moulds which grow on oil or oily substances, and is so filthy in its habits as to flourish in the sewers and cesspools of cities. It is so much like Fig. 2 in structure and manner of fruiting, though many times larger, that it must pass without an illustration.

The pulp of oranges is an especially favorable diet for some of the most delicate moulds. A culture made of it will show decided signs of mouldiness in twenty-four hours, and after thirty-six hours of growth there is a fine crop for study. Those which we have seen on the bread are invariably the first to appear here, though followed in a short time by others, one of the most common of which is given in Fig. 5. At the base *a* are some mycelial threads which penetrate the tissue of the pulp, and from them, as they come to the surface, arise the fruit-stalks which branch near the top into a loose head with the spore capsules borne on the ends of the branches. At *c* is one of the *Sporangia* more highly magnified, showing the spores to be larger and few in number as compared with the *Mucor*. This species is a member of the same family with those already mentioned, and has its similar zygaspores.

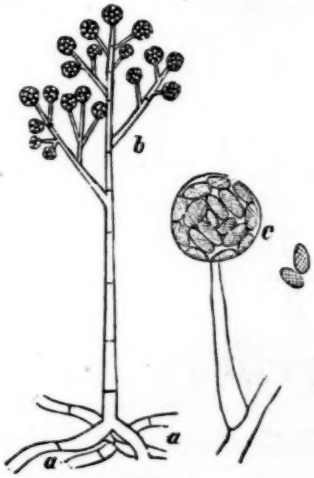


FIG. 5.

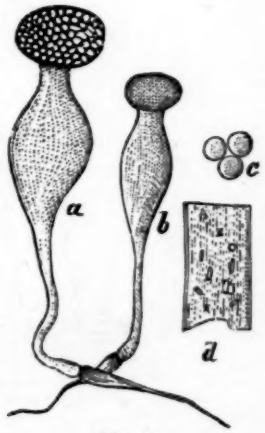


FIG. 6.

Corn-starch pudding, when placed in a bell-jar, remained unchanged until the fourth week, when its surface became coated with a peculiar yellow-colored substance, and a day or so after black specks began to appear. When viewed with the microscope, this mould exhibited the structure seen in Fig. 6. There arises from the unbranched and imbedded filaments a very much swollen end (*a* and *b*) filled with protoplasm, yellow globules of oil, and crystals (*d*). As this end increases in size, a contraction takes place near the upper end, and soon a distinct spore capsule is formed of the end thus separated. When the plant is ripe a black elastic coat covers the spore-case, which slips partly off when the spores are discharged from below. There are several spe-

cies growing on various substances, which have the general structure of Fig. 6.

We now come to the most common of all the members of the group of moulds: the blue mould of cheese, bread, and almost every article of food. In its diet, it does not confine itself to those things found in a well-stocked pantry, but will flourish on old boots and other articles of clothing when they are left for a few days in a warm, damp place. No culture was made without its making its appearance, and often to the exclusion of all other forms. It is quite small, never reaching but a very short distance from the substance on which it grows, and under favorable circumstances forms an even blue crust over the surface of the nourishing material whether boots or bread. The structure of this frequent and often unexpected and unwelcome visitor is given in Fig. 7. Two fully-developed fruit-stalks are seen at *a* and *b*, branching

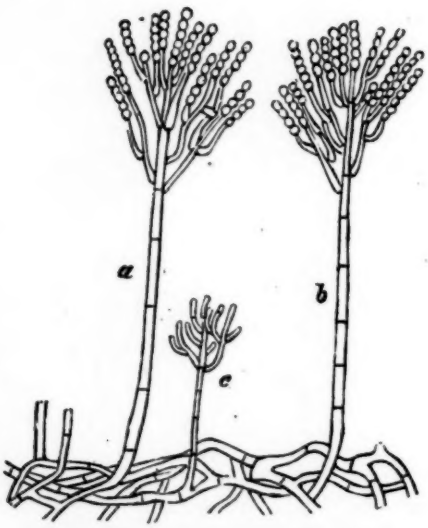


FIG. 7.—PENICILLIUM CRUSTACEUM. FR.

irregularly at the top, and bearing the naked spores in chains at the ends of the filaments. At *c* is a young stalk before the spores have formed from the threads, which is done by a constriction, a familiar but perhaps rude illustration of which is seen in the making of the links of sausage. As the spores fall away, new ones are formed below, and so the process of producing these simplest of reproductive bodies is indefinitely continued. At the base *d* are the threads which penetrate the nourishing substance, on some of which are formed, as the result of sexual action, spherical bodies which inclose the more enduring sexual spores. From this method of forming subterranean fruit this little mould is a close relative to the truffle so highly prized for food.

With the spores of this mould repeated sowings have been made, with gratifying results. When a slice of fresh bread was placed in the bell-jar and certain marked places were sprinkled with spores by means of a pair of forceps, in the course of twenty-six hours those spots sown were covered with the young mould, while all other places were entirely free from it. In one case a fresh slice of bread was wrapped in a piece of paper, with the exception of a star-shaped figure cut from the paper, which came in the middle of the slice. Over the whole a slice of mouldy bread was shaken so gently that no spores were seen to fall; the paper was then carefully removed, and the bread placed under the bell-jar. After the usual time a fine star of blue mould made its appearance, soon spreading over the whole of the bread. One could as easily write his name in mould on bread as with clover-seed upon the soil, though it would not be as enduring an inscription.

It seems difficult for some people to see how the spores of these various moulds can exist almost everywhere, ready to grow when the first opportunity offers itself. With the hope of making this matter appear clearer, the following calculations have been carefully made: The blue mould (*Penicillium crustaceum*) is very favorable for the estimation of the number of spores produced, as the heads are quite open, and the spores are naked and distinct.

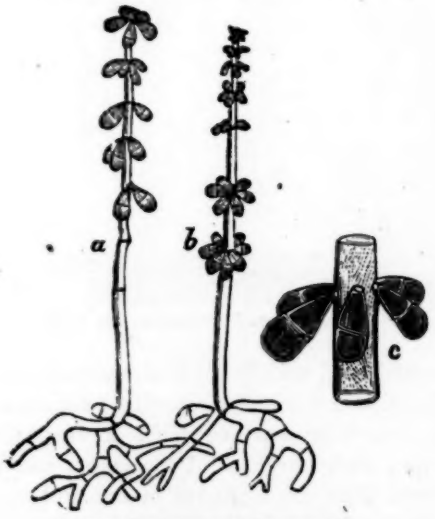


FIG. 8.—TRICOTHECIUM ROSEUM. Fr.

A piece of decaying apple was selected, because the mould can be removed from that portion covered with the smooth skin without being mixed with foreign matter. When the mould was still young and no spores had fallen away, it was viewed with the high power of the microscope. There were usually twenty filaments to each head, and twenty spores on a filament, or 4,000 spores to a head or single stalk.

A small tuft was then carefully taken from the apple, and placed on a glass slide, and its area measured with the micrometer, and the number of fruit-stalks it contained determined. The surface was $\frac{1}{100}$ of an inch square, and the number of stalks 800. As the square inch is a familiar unit of measurement, the estimate made for that small extent of surface gives 3,200,000,000 spores. It is a well-known fact that not only inches, but feet, and even acres of this mould are produced, and the number of spores for daily use must be perfectly appalling. They are light, airy, and invisible to the naked eye and therefore ecape our notice; were they female mosquitoes, we would realize their nearness and number. With such multitudes of germs produced we need not wonder that the sowing for moulds should be natural and complete. The light which the microscope throws upon this subject makes it unnecessary to resort to "spontaneous generation" to account for the almost certain growth of mould when the proper conditions are combined.

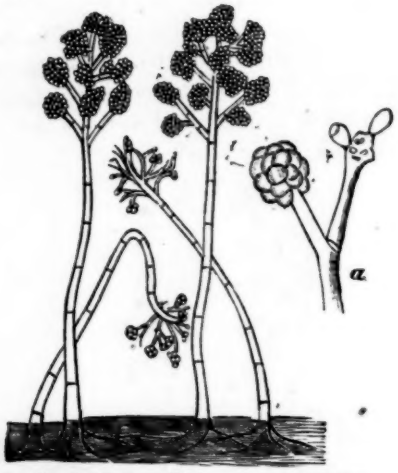


FIG. 9.—PEZIZA FUCHELIANA. De Bary.

When a slice of bread which has been thoroughly overrun by the *Penicillium* is left under the bell-jar, another mould almost invariably comes, covering the blue surface with a rose-colored coat. The asexual spores and their method of formation are given in Fig. 8. It will be observed that the fruit-stalks are unbranched, the spores when mature always double, and arranged on the stalks in whorls. The development is from below upward: *a* showing an old stalk with the youngest spores nearly ripe, and some of the older ones gone from their attachments; at *b* is a younger stalk, where the older whorls are complete and the upper ones small and indistinguishable; *c* is a more enlarged view of a cluster of ripe spores. After this mould, which is of slow growth, has run its course, the bread seldom produces any other forms, and for further study a new culture must be made.

In Fig. 9 is given a mould which makes its home on decaying herbage, and is found to perfection in old waste-heaps where weeds and other green matter have been deposited. So common is it, that a culture is more a matter of convenience than necessity. The fruit-stalks are upright, considerably branched at the top, with the spores borne in bunches at the ends of the filament. At *a* is a much enlarged view of one of these naked heads of spores, and another where the spores have mostly fallen away. As the fruit-stalks grow old they break down in every way, giving the appearance of a forest over which a tempest has passed.

Of the black moulds Fig. 10 shows a common and very simple representation. It grew as a sooty coating on a culture made of sliced raw potatoes. It is so very simple that any space taken for description seems unnecessary. The black spores are nothing more than portions of single or branched filaments cut off in a very regular manner.

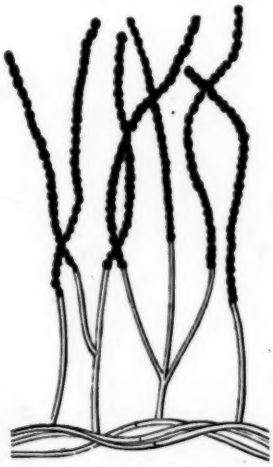


Fig. 10.

Fig 11.

In Fig. 11 is given the general structure of a large number of related moulds which grow wherever they can get a foothold. The drawing was made from one found on some turnip-roots left upon the ground over winter. Like many others, it forms an olive-brown, velvety coating of considerable thickness; and, because of their low habits and inobtrusive nature, they pass readily for dirt or decay, and are seldom noticed. They are the lowly forms which some of the highest of the fungi assume in passing through one stage of their polymorphic existence.

A score of other species of moulds deserve mention here which are found on various substances either forced under the bell-jar, or growing naturally; but we know how unattractive such descriptions would be without accompanying figures, and therefore pass them by.

For the last place in this brief enumeration we have reserved one of the most common of household moulds. It is the prince of moulds, and claims relationship with the most perfect and beautiful of fungi. In diet it is something of an epicure, and may well be called the cake and preserve mould, and on those substances the best results are always obtained when used for its culture. Though preferring its cake and preserves, it was induced to grow on a tempting dish of stewed prunes, which afterward furnished the substance for its culture.

To the naked eye this mould at first appears as white patches; soon stalks rise from the surface, and on the end of each a small spherical head is borne, which increases in size and turns to a bluish color, so that when this mould is ripe the surface of the nourishing substance does not differ greatly in color from the *Penicillium* on the bread, though this mould is much taller and more inclined to grow in tufts. Under the microscope the tip of a very young filament which is to form a head of spores is seen to be perfectly smooth and similar to those in the *Mucor*, but very soon small peg-like projections begin to grow from its surface, which increase in size and finally divide, forming radiating rows of spores.

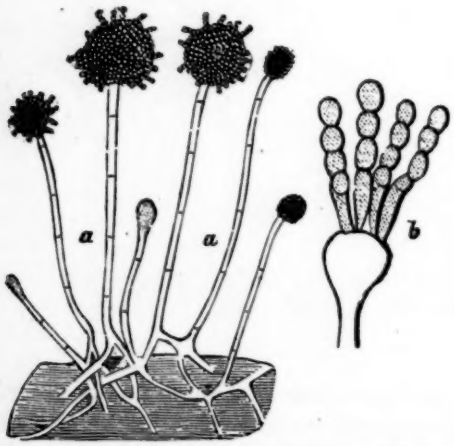


FIG. 12.—EUROTIUM ASPERGILLUS GLAUCUS. De Bary.

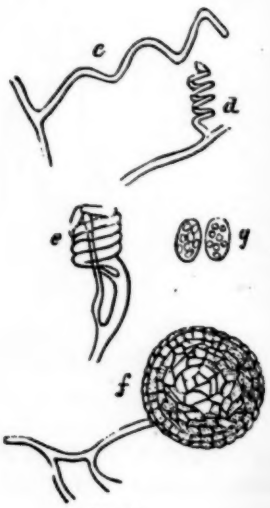


FIG. 13.

Various stages in the development of the asexual fruiting of this mould are shown in Fig. 12, *a*, *a*, with a view of an imaginary cross-section through one of these heads highly magnified in *b*, giving the method of attachment of the spore-threads.

Shortly after the heads have formed, the sexual fruit begins to develop on the mycelium at the base of the fruit-stalks. The method is more complicated than in any of the moulds already given, and places this plant among the most highly developed of fungi. The process begins with the coiling of the end of a thread in a corkscrew manner

as seen in *c* and *d* (Fig. 13). The coils grow closer together as the filament increases in size, until a hollow cylinder is formed. From the same threads below the base of the coil one or more processes grow out which are the male organs, and, where one of these threads reaches the tip of the female coiled filament, that organ is fertilized. From this time on, this body undergoes various and complicated changes, which finally result in a bright-yellow spherical body (Fig. 13, *f*), which consists of a thin wall inclosing a large number of sacs, *g*, each of which contains eight spores.

To find all these various stages of development is a matter of some time and patience; but nothing is more satisfactory in the study of moulds than to trace all these steps, from the first bending of the filament to the perfect sphere with its multitude of spores.

For a long time these two forms of fruit in the *Aspergillus* were considered as belonging to distinct and widely-separated species, but, when the microscope shows that they are produced from the same mycelium, it is time to conclude that they are but two methods of continuing the same species.

Space forbids further details concerning our common moulds; but it is hoped enough has been said to show that among them the species are distinct. The tiny forests which the microscope reveals are made up of forms as decided as those which compose our woodlands and groves. In closing, the reader expects an answer to the question which very naturally arises, viz., "What good do they do?" Though often of great annoyance in domestic and other affairs, yet all in all it is safe to say the good they accomplish far overbalances the harm. They are scavengers which do in their own inobtrusive way a vast amount of sanitary work. Though small in themselves, they are great reducing agents, striving to bring about that equilibrium so necessary to perfect harmony in the organic world. They hasten decay, tear down the accumulating rubbish around us, and allow the elements thus liberated to pass again into the cycle of ceaseless activity and growth.

To the thoughtful mind moulds do not simply excite wonder or disgust, but teach a deeper lesson of adaptation and service of little things, in the perfect and economical scheme of creation.

WHAT ARE SPECIES?

By Prof. T. H. HUXLEY.

IN its most general acceptation the word "species" signifies a kind or sort of something, which something is the *genus* to which the species belongs. Thus, a black stone is a species of the genus stone; a gray horse is a species of the genus horse; a scalene triangle is a species of the genus triangle; and, generally, it may be said that

every adjective denotes a species of the genus indicated by the substantive to which it is applied.

In the technology of the physical sciences the term "species" has a more restricted signification. It is used to denote a group of individuals which corresponds with an early stage of that process of abstraction by which the qualities of individual objects are arranged in the subordinated categories of classification.

The individual object alone exists in Nature; but, when individual objects are compared, it is found that many agree in all those characters which, for the particular purpose of the classifier, are regarded as important, while they differ only in those which are unimportant; and those which thus agree constitute a species, the definition of which is a statement of the common characters of the individuals which compose the species.

Again, when the species thus established are compared, certain of them are found to agree with one another, and to differ from all the rest in some one or more peculiarities. They thus form a group, which, logically, is merely a species of higher order, while technically it is termed a "genus." And, by a continuation of the same process, genera are grouped into families, families into orders, and so on. Each of the groups thus named is in the logical sense a genus, of which the next lower groups constitute the species.

The characters on which species are based necessarily depend upon the nature of the bodies classified. Thus, mineral species are founded upon purely morphological characters; that is to say, they are defined by peculiarities either of form, color, and the like, or of structure, which last term may be used to include both the physical and the chemical characteristics of a mineral. The distinction between a species and a variety is wholly arbitrary, except so far as it is commonly agreed that individuals which differ from others only as terms of a gradual series of modifications belong to the same species, and are to be considered merely as varieties of that species.

It is conceivable that animals and plants should have been known to us only by their remains preserved in museums or in the fossil state. If this had been the case, biological, like mineralogical species, could have been defined only by morphological characters; that is to say, by the peculiarities of their outward form and inward structure; and, as a matter of fact, this is the state of our knowledge in respect of a large proportion of the existing fauna and flora of the world, and of all extinct animals and plants.

A botanist or a conchologist who sets to work to arrange a newly-received collection sorts his plants or his shells out according to their likenesses and unlikenesses of form and structure, until he has arranged them into groups of individuals which agree in certain constant characters and differ only by insignificant features, or by such peculiarities as vary in different individuals in such a manner that an insensible

gradation can be traced between those forms which have the peculiarity strongly marked and those in which it is absent.

Thus far the considerations which guide the biologist in the establishment of species differ in no respect from those which influence the mineralogist.

But although naturalists have no more direct knowledge of any but the morphological character of the great majority of the species of animals and plants than they would have of so many mineral specimens, they are familiar with many animals and plants in the living state when they exhibit phenomena to which the mineral world presents no parallel, and the study of these phenomena of active life has complicated the conception of species in biology, by adding physiological to morphological considerations.

The fact that living beings originate by generation from other living beings is one of the circumstances in their history which most completely differentiates them from minerals. This process of generation enters in various ways into the conception of biological species.

For example, it is a generally assumed axiom in biology that whatever proceeds from a living being by way of generation is of the same species as that from which it proceeds, whether the morphological differences between parent and offspring be great or small. The two sexes are often extraordinarily different, and in cases of the so-called alternation of generation the successive zoöids may differ very widely; but, inasmuch as the differing forms in these cases proceed from the same parents, no one doubts that they belong to the same species. The breeds of domesticated animals and plants often differ morphologically as widely as admitted species, but, apart from other considerations, historical evidence that they have the same parentage suffices to cause them to be regarded as of one species. It is not quite clear that the converse of the axiom which has just been referred to would be admitted, and that living beings which arise from totally distinct parents are of different species, even though morphologically identical. The wellnigh exploded hypothesis of the multiplicity of centres of origin for species of wide distribution implies the belief that groups of individuals which have proceeded from distinctly-created parents may, nevertheless, be of the same species, while the supporters of the no less nearly extinct hypothesis of the independent creation of the fauna and flora of successive formations used to affirm that, although indistinguishable, two forms from separate formations must be of distinct species, because they had been created separately. However, these subtilties have ceased to have any practical importance.

In the next place it is observed that, while individuals of the same morphological species breed freely with one another and give rise to perfectly fertile offspring, the unions of individuals of different morphological species are, as a rule, either unfertile or imperfectly fertile.

Thus fertility, like parentage, has become a physiological character of species; and, though in the case of some domesticated animals, as pigeons, the extreme forms are more different from one another than many morphological species, yet they, apart from the historical evidence of their parentage, are held to be members of the same species, because they are all perfectly fertile one with another, and their offspring are also perfectly fertile.

Thirdly, it is a matter of experience that, as a general rule, and taking the whole cycle of forms through which a living being runs into account, offspring and parent are so similar that they belong to one and the same morphological species; and it is further in evidence that many species have endured for extremely long periods without any notable difference being discernible between ancestor and descendant. Moreover, in some cases, varieties are found to revert to the character of the species from which they have proceeded. The conclusion has been drawn that the character of species is physiologically fixed; that is to say, that, however long the process of generation may be continued, the individuals either retain the identical morphological character of the oldest ancestor, or, if they vary, the varieties remain fertile with one another.

Assuming that species have the physiological character thus enumerated, certain conclusions respecting the "origin of species" are inevitable. It is clear that no existing species can have arisen by the intercrossing of preëxisting species, or by the variation of preëxisting species, but that every species must have existed from all eternity, or have come into existence suddenly in its present form, which is the objective fact denoted by what is termed creation.

At the dawn of modern biology, a century ago, no scientific evidence respecting the real history of life on the globe was extant, and, for any proof that existed to the contrary, species might have been of eternal duration. But philosophical speculation combined with theological dogma not only to favor the contrary opinion, but to lead the most philosophic naturalist of his day to embody the hypothesis of creation in a definition of species. "Totidem numeramus species quot in principio formæ sunt creatæ" (we reckon as many species as there were forms created in the beginning) is the well-known formula of Linnæus.

In practice Linnæus regarded species from a purely mythological point of view; in theory, he assumed the common ancestry and the limited variability of species, though he was disposed to allow more freedom in this direction than most of his successors. On the other hand, he seems to have attached comparatively little weight to the assumed sterility of hybrids, and to have held a sort of modified doctrine of evolution, supposing that existing species may have been produced by the interbreeding of comparatively few primordial forms.

It is mainly to the influence of Cuvier's authority that we owe the general acceptance of the views respecting the physiological character of species, which up till within the last few years have been almost universally prevalent.

In the introduction to the "Règne Animal" (1816), Cuvier writes:

"There is no proof that all the differences which now distinguish organized beings are such as may have been produced by circumstances. All that has been advanced upon this subject is hypothetical; experience seems to show, on the contrary, that, in the actual state of things, varieties are confined within rather narrow limits, and, so far as we can retrace antiquity, we perceive that these limits were the same as at present.

"We are thus obliged to admit of certain forms, which since the origin of things have been perpetuated, without exceeding these limits; and all the beings appertaining to one of these forms constitutes what is termed a *species*. Varieties are accidental subdivisions of species.

"Generation being the only means of ascertaining the limits to which varieties may extend, species should be defined, *the reunion of individuals descended from one another, or from common parents, or from such as resemble them as closely as they resemble each other;* but, although this definition is vigorous, it will be seen that its application to particular individuals may be very different when the necessary experiments have been made."

It need hardly be said, however, that in practice Cuvier founded his species upon purely and exclusively morphological characters, just as his predecessors and successors have done. The combination of Cuvier's views on the fixity of species with the discovery of the succession of life on the globe, which was so largely the result of his labors, led his successors into curious difficulties. Developing the fundamental idea of the "Discours sur les Révolutions de la Surface du Globe," naturalists were forced to conclude not only that existing species are the result of creation, but that the creative act by which they were brought into being was only the last repetition of a series of such acts by which the often depopulated world has been as frequently repeopled, and thus orthodox belief respecting the existing flora and fauna led to a terribly heterodox cosmogony.

The contemporary and countryman of Cuvier, Lamarck, must be regarded as the chief founder of the reaction against the doctrines which Cuvier advocated—a reaction which, overpowered and disregarded for many years, has acquired such force since and through the publication of the "Origin of Species," that it has almost swept opposition away. Lamarck's vast acquaintance with the details of invertebrate zoölogy rendered him familiar with the great variability of many species, and led him to see that variation is in some way related to change of conditions; the frequent occurrence of transitional forms between apparently distinct species, when large suites of specimens (especially when they are obtained from different parts of a wide geographical area) are examined, tended to bring into strong

light the tenuity of the distinction between species and varieties. The fact of embryology, the occurrence of rudimentary organs, and the fundamental unity of structure which obtains in vast groups, such as the vertebrata and arthropoda, all tended to suggest the existence of a genetic connection between species, so that Lamarck was finally led to renounce the doctrine of the fixity of species, and to define a species as "a collection of individuals which resemble each other and produce their like by generation, so long as the surrounding conditions do not alter to such an extent as to cause their habits, characters, and forms, to vary."

According to this definition the distinction between species and variety once more becomes conventional. A variety is, in fact, a nascent species; and the notion of the creation of species vanishes, inasmuch as every species is the result of the modification of a predecessor. Lamarck's views of the nature of geological changes were in harmony with his biological speculations, and wholesale catastrophic revolutions were as completely excluded from the one as from the other.

It is impossible to read the "Discours sur les Révolutions" of Cuvier, and the "Principes" of Lamarck, without being struck with the superiority of the former in sobriety of thought, precision of statement, and coolness of judgment. And it is no less impossible to consider the present state of biological science without being impressed by the circumstance that it is the conception of Lamarck which has triumphed, and that of Cuvier which has been utterly vanquished.

Catastrophic geology has vanished out of sight, and is everywhere replaced by the conception of slow and gradual change. With it has disappeared the once prevalent notion that the whole living population of the earth has been swept away and replaced in successive epochs. On the contrary, it is now well established that the changes which have taken place in that population have been effected by the slow and gradual substitution of species for species.

Moreover, it is well established that in some cases the succession of forms in time is the same as that which should have occurred if the hypothesis of evolution is correct.

The rapid advance of comparative anatomy has diminished or removed the wide intervals which formerly appeared to separate the different divisions of the animal and vegetable kingdoms from one another. Even the hiatus between the vertebrata and the invertebrata is bridged over by recent discovery. The establishment of the cell-theory, however much the views originally propounded by Schwann have been modified, leaves no doubt that there is a fundamental similarity in minute structure, not only between all animals, but between them and plants, while the discoveries of embryologists have proved that even the most complex forms of living beings do, in

the course of their development, run through a series of changes of the same order as those which are postulated by the evolution-theory for life in time.

Again, the facts of geographical distribution, as now known, are absolutely incompatible with the hypothesis that existing animals and plants have migrated from a common centre, whether Mount Ararat or any other; and, by demonstrating the similarity of the existing fauna and flora of any locality to that which inhabited the same area in the immediately precedent epoch, have furnished a strong argument in favor of the modifiability of species. Thus, it is not too much to say that the facts of biology known at the present day are all consistent with and in favor of the view of species entertained by Lamarck, while they are unfavorable to, if not incompatible with, those advocated by Cuvier; and that, even if no suggestion has been offered, or could be offered, as to the causes which have led to the gradual evolution of species, the hypothesis that they have arisen by such a process of evolution would be the only one which would have any scientific foundation.

The great service which has been rendered to science by Mr. Darwin, in the "Origin of Species" is that, in the first place, he has marshaled the ascertained facts of biology in such a manner as to render this conclusion irresistible; and, secondly, that he has proved the following proposition: Given, the existence of living matter endowed with variability, the interaction of variation with the conditions of existence must tend to give rise to a differentialism of the living matter into forms having the same morphological relations as are exhibited by the varieties and species which actually exist in Nature.

What is needed for the completion of the theory of the origin of species is, first, definite proof that selective breeding is competent to convert permanent races into physiologically distinct species; and, secondly, the elucidation of the nature of variability. It is conceivable that both the tendency to vary and the directions in which that tendency takes effect are determined by the molecular constitution of a living body, in which case the operation of the changes of external conditions will be indirect, and, so to speak, permissive. It is conceivable, on the other hand, that the tendency to vary is both originated and directed by the influence of external conditions, while it is also conceivable that both variation and the direction which variation takes are partly determined by intrinsic and partly by extrinsic conditions.—*The American Cyclopædia.*

MALARIA.[1]

By CHARLES P. RUSSEL, M. D.

THE terms *malaria* and *miasm* in medical phraseology include the causes of a large class of affections—what are known more particularly as *zymotic* diseases, which depend upon a variety of specific organic poisons whose essential nature, composition, and form, are mostly inappreciable as yet by scientific research. The general understanding, however, of these terms, is more limited; and, in conformity with the popular idea, I shall in the present paper confine their application to the cause of those wide-spread disorders, *intermittent* and *remittent* fevers—the former of which is so well known as "chills and fever" or "fever and ague."

"Time out of mind," as Watson remarks, "it had been matter of common observation that the inhabitants of wet and marshy situations were especially subject to these definite and unequivocal forms of disease." The same natural agencies which are now at work elaborating, evolving, and disseminating malaria must have been equally in operation ever since the surface of the earth assumed its present condition. Vast and remote wildernesses that have never known human presence teem, as of yore, with deadly exhalations that almost preclude the bold attempts of enterprising man to lay bare their secrets. There are some parts of India, as Bishop Heber informs us, which even monkeys and other wild animals instinctively desert between April and October of each year. The tigers go up to the hills; the antelopes and wild-hogs make incursions into the cultivated plains; and those persons, such as *dâk-bearers* and military people, who are obliged to venture into the marshy jungles, agree that not so much as a bird can be heard or seen in the frightful solitude.

The celebrated Pontine Marshes may be regarded as the classic home of malaria. The older historical records describe this tract as occupied with numerous towns by the Volsci. It was evidently a fertile region; for we read in Livy that the early Romans sent thither during a season of scarcity for a supply of corn. Three hundred and twelve years B. C., the Censor Appius Claudius Cæcus constructed the Appian Way across the length of the Pontine region, the soil of which must then have been sufficiently compact to support the heavy causeway. At some period of the subsequent century and a half, the country seems to have undergone great deterioration either from natural or civil causes, and to have become partially inundated; for, about 170 B. C., we find the Consul Cornelius Cethegus applying himself to draining the marshes, and restoring the land to cultivation and salu-

[1] A portion of a paper read before the New York Public Health Association, April 13, 1876.

brity. The result of his efforts was, that new and flourishing towns arose on the ruins of the ancient Volscian cities. The civil wars, however, and the devastation which accompanied them, again caused the hydraulic works of the Pontine Marshes to fall into neglect, until they were repaired by Augustus, who constructed several new canals, especially a navigable one skirted by the Appian Way. It was on this canal, at Forum Appii, that Horace embarked one evening, and at the same spot St. Paul first met his countrymen from Rome. Nerva and Trajan both contributed to the drainage of the Pontine Marshes, and left inscriptions, still extant, which testify to their great interest in the project. During the convulsions of the following centuries they were overflowed anew, until in the reign of Theodosius they were once more drained, with most beneficial effect, by a public-spirited individual named Cæcilius Decius. We have no subsequent account of the condition of this region until the end of the thirteenth century, when Pope Boniface VIII. constructed some works to drain it. Leo X. employed the engineer Giovanni Scotti to repair and enlarge the canal of Badino, the principal outlet of the marshes, and Sixtus V. built a large lateral canal. The most important improvements, however, were effected by Pius VI., and a system of effectual drainage was almost completed, when the low condition of the papal treasury and the confusion attendant upon the French Revolutionary invasion completely arrested the undertaking, which up to that time had involved an expense equal to $1,622,000. No new works have since been attempted, although the authorities endeavor to keep the canals clear and the dikes in repair. The greater part of the plain is covered with rich pastures; but, except the post-stations along the highway, and some scattered huts of herdsmen, it has and can have no permanent population.

Taking the United States census of 1870 as a guide for our own country, we find malarial fevers forming a very important feature of the mortality-tables. They are most fatal in Florida, Louisiana, and Texas. Next in order follow Arkansas, Mississippi, Alabama, Georgia, Missouri, Kansas, and Nevada. In another group distinguished by a somewhat less mortality we find New Mexico, the Carolinas, Virginia, Tennessee, Kentucky, Illinois, and Indiana. Those States marked by the lowest mortality are the New England and Middle States, Wisconsin, and Minnesota. In California there is a considerable ratio of mortality, diminishing easterly in Utah, and northerly in Oregon and Washington Territory, while it augments largely toward the south in New Mexico. Since the census was taken, however, that is, since about 1869, there has been noticed an evident extension of the subtile miasmatic agency over regions previously exempt from it, in the Middle and New England States. The increase of mortality by this cause in New York City has been notable, but can scarcely be attributed entirely to local influences. In 1868 there were registered in this city

only 98 deaths from malarial fevers. In 1869 they rose to 128; in 1870, to 213; in 1871, to 291; and in 1872, to 348: an increase of 350 per cent. in four years. Since then some diminution in their fatality has occurred. They occasioned 282 deaths in 1873, 295 in 1874, and 275 in 1875.

Let us now consider under what circumstances malaria may be produced. Although it cannot be denied that there are peculiar localities where, with apparently every presumed condition existing for the development of malaria, that poison is entirely absent, yet the concurrence of malarial emanations with such conditions in innumerable places establishes beyond a question their direct relation. The *essential* element in the production of malaria would appear to be *vegetable decomposition;* and, in order that this process shall ensue, the simultaneous operation of *air*, *moisture*, and *a certain high range of temperature*, is absolutely required. Localities, therefore, where such combination occurs, are prolific of malaria. Of this character are swamps and morasses, alluvial deposits, loose, porous, sandy, and argillaceous soils, or deep, loamy, marly lands underlaid by impermeable strata affording capacity for the retention of moisture, regions exposed to periodical or occasional inundation, places left bare by the subsidence of lakes or drying up of streams, and particularly areas subject to the intermingling of salt and fresh water—as salt-marshes into which fresh streams discharge, or regions liable to tidal overflow and recession.

The exhalations from marshy tracts are recognized by their effects upon the human system throughout the world; and the fact that marshes bear a causative relation to malaria has been demonstrated in numerous instances by the disappearance of fever after thorough drainage and cultivation, and its reappearance upon their being allowed to relapse into neglect. The favorable effect of drainage and cultivation is owing both to the systematic removal of water near the surface, and most probably also to the absorption by the growing crops of the products of organic decomposition. On the same principle Prof. Maury succeeded in antagonizing the noxious emanations from a marsh surrounding the observatory at Washington by planting it thickly with sunflowers, which seem to possess an extraordinary absorbing power. Sebastian is inclined to believe that the *Calamus aromaticus* which grows in some swamps has a similar neutralizing quality. Swamps covered with water are not so dangerous as those partially dry, the layer of water serving as a protection against the access of air and heat to the vegetable matter underneath.

A certain continuous range of temperature seems essential to the development of malaria, which is almost unknown beyond 60° north and 57° south latitude, and during the cold season in the temperate zone. According to Hirsch, it prevails up to various degrees of latitude and average annual temperature. It is the average summer tem-

perature, however, that is of account, and the northern limit of this lies between the isotherms of 59° and 59.8° Fahr., giving a prolonged temperature sufficiently high to insure vegetable decomposition.

The alluvial soil along the banks of rivers and at their deltas, as those of the Ganges, Nile, Orinoco, and Mississippi, gives rise to fevers of a very malignant type. Their banks are subject to overflow, and frequently have a clayey subsoil, presenting an obstacle to percolation —thus upon the river's receding into its ordinary channel its banks remain damp below the surface, and disease is generated by the sun's agency. A like process annually takes place in the extensive plains and table-lands formed of alluvium washed down from mountain-ranges during the lapse of centuries, and having few actual marshes. Profuse rains, succeeded by dry hot seasons, render such regions exceedingly insalubrious during certain periods of the year. Somewhat similar in character are the oases of the Desert of Sahara, which abound in malaria. Hirsch describes these spots as consisting of trough-like depressions in a rocky or highly-hygroscopic soil, the receptacle of subterranean waters, and covered with a layer of alluvium, the surface of the oasis. In this the fierce heat of the sun causes cracks and deep rifts in the earth, which give free vent to the miasm evolved from beneath.

Sandy plains, especially when at the foot of tropical hills and covered with vegetation, as the "Terai" at the base of the Himalayan range, are often infested with malaria. In other cases sandy plains at a distance from hills, apparently dry and not subject to variations in the ground-water, are equally sources of the poison. Such instances as the latter might seem to militate against the generally-accepted theory, but actually do not. Some sands which appear quite free from organic admixture are really the reverse. Faure has pointed out that the sandy soil of the Landes in Southwestern France contains a large amount of organic ingredient which is constantly decomposing and gives rise to periodic fevers. Under such sands, moreover, there is frequently a subsoil of clay. Here, then, assuming a continued high range of temperature, we find all the conditions necessary for the production of malaria.

Localities subject to the intermixture of salt and fresh water are particularly prone to malaria. The Maremmas of Italy afford examples of this on a large scale. The Maremma of Lucca consists of three basins formerly dotted over with ponds and pools. It had been for centuries frequently overflowed by the sea-tides which intermingled with its fresh ponds. Malarial fevers ravaged it and rendered it almost uninhabitable. To the wayfarer who was so imprudent as to spend a night of August or September within its desolate bounds, the penalty was almost certain death. A remedy for this deplorable condition of things was long sought. A proposition had been made in 1714 by the engineer Rondelli to attempt the exclusion of the sea.

Renewed in 1730 by Manfredi, and six years later by Zendrini, a mathematician of Bologna, the idea was finally carried into execution in 1740. The initial attempt was made upon the principal and most unhealthful basin. A sluice was constructed at the entrance of the canal of Burlamacca through which the waters of the sea penetrated into the basin to its central pond. The flood-gate was so arranged as to act like a valve, shutting by the pressure of the rising tide and opening when it fell. The success of this enterprise was so complete that in the following year the miasmatic diseases which had never failed to show themselves annually did not reappear, and the whole district was rendered salubrious. It was at this period that the village of Viarregio, previously abandoned and composed only of a few fishers' huts grouped at the foot of an old tower where galley-slaves were confined, became a place of fashionable resort during the summer for the aristocracy of Lucca. This fact of a region's being rendered healthy by the exclusion of sea-water is curious, but made more decisive still by its counter-proof. In 1768–'69 fevers suddenly sprang up again as bad as ever in the same territory. Upon the cause being investigated, it was found that the sluice had become deranged and the mixture of waters had been reëstablished. Upon the flood-gate being repaired, the malaria was again extinguished. The same occurrence happened in 1784–'85. The sluice having been neglected, there took place in 1784, out of a population of 1,900, the enormous number of 1,200 cases of malarial fever and 92 deaths. In the following year there occurred 103 deaths. The trouble was remedied in the same manner as before. The other portions of the Maremma were rendered healthy later, by sluices successively established at different points. Such a remarkable result necessarily attracted public attention. Leopold II., Grand-duke of Tuscany, was particularly impressed by it, and he conceived the great idea of improving the whole Tuscan Maremma in the same manner. It was an immense undertaking which he contemplated—an actual transformation of a large part of his dominions—and it redounds to his glory that he succeeded, in the face of almost insurmountable obstacles, by the means described, and a properly-directed system of canalization and field-culture, in regenerating a very considerable portion of his territory.

It is not difficult to account for the generation of malaria under such circumstances as those just mentioned. The minute forms of vegetable life with which both fresh and salt water teem require their own special element for continued existence. The intermixture of salt with fresh water introduces a new element with which the life maintained in each separately is incompatible. The surface of the soil consequently after every invasion and retirement of the tide exposes to the action of the heat a mass of defunct vegetable material spread out over an extensive area, and in most favorable condition for speedy decomposition.

Besides the localities enumerated, malaria is apt to be induced or intensified in a region wholly or comparatively exempt from it before, during the disturbance of large extents of soil, as in the construction of canals, roads, railways, fortifications, and dikes, rooting out of timber, preparation of virgin land for cultivation, etc. Vegetable organisms previously hidden and protected underground are thus brought to the surface and exposed to the agencies of putrefaction. Laborers engaged in such works and the neighboring inhabitants soon suffer. The "polders" of Holland, those parts reclaimed from the sea by the erection of dikes, are of this character, and the workmen engaged on them are attacked with malarial troubles of great severity. In this country such instances are common. We have an example at our very doors in the increase of malarial fevers which accompanied the opening of the new boulevards, and the engineering excavations of the Harlem Railroad. After such works have been completed, however, it is not unusual for the vicinity to be restored to healthfulness.

It must be acknowledged that occasionally miasmatic fevers appear and disappear without there having occurred any perceptible changes in the relations of the soil. Such circumstances were reported to the Pennsylvania State Medical Society as having been noticed in 1856 along the Juniata River. Reports to the Connecticut State Medical Society also mention the appearance of miasmatic disorders without any recognized cause in portions of the State previously exempt from them.

There would appear to be some connection between such phenomena and the fluctuating level of the subsoil-water as affected either by rainfalls or subterranean forces. According to Jilek's figures, in Pola, a noted malarious district of Istria, between 1863 and 1868 the number of persons attacked by fever varied from fourteen to fifty-one in every one hundred inhabitants, in exact proportion as the rainfall had varied from one to eighteen inches.

We know that the level of the ground-water is constantly changing. It rises and falls more or less rapidly, and at different rates in different places—in some only a few inches either way annually, but in many places several feet. In Munich, its limit was found by Pettenkofer to be about ten feet. In India, the changes are greater. At Saugor, in Central India, the extremes are between a few inches from the surface during the rains, to seventeen feet in May. At Jubbulpore it varies from two to fifteen feet from the surface. The causes of such changes are rainfalls, pressure of water from seas or rivers, and ob struction of outflow. The pressure of the Rhine has been observed to affect the water in a well 1,670 feet distant from the river. An impeded outflow which raises the level of the ground-water has been productive of an immense spread of paroxysmal fevers. Demster, Taylor, and Ferguson, have reported such to have been the case in

portions of India. The severe and fatal fevers prevailing in Burdowan, Lower Bengal, during the last fifteen or twenty years, have been coincident with obstruction to the natural drainage from mills, and blockage of water-courses. The same cause has doubtless operated to a great extent in producing the fevers of Bloomingdale, Manhattanville, Yorkville, and Harlem. The establishment during the past five years of extensive subsoil drains in those portions of New York has had a visible tendency to diminish the area of malaria. A similar result on a large scale has been noticed in Lincolnshire and other parts of England, where many malarious tracts have been rendered quite healthy by similar measures, having for their object the lowering of the subsoil water-level by an increased outflow.

I have thus far confined my observations to endemic malaria. But, like other diseases dependent upon telluric or organic emanations, miasmatic fevers occasionally assume an epidemic character, and, breaking loose from their native haunts, overspread a wide extent of territory. Thus, as Hertz informs us, nearly the whole of Europe was invaded by such epidemics in 1558—in 1678–'79—from 1718 to 1722—from 1824 to 1827—and from 1845 to 1848. The cause of malaria being thus propagated is as mysterious as that of most epidemics. It is possible that such an epidemic malarial influence has been prevailing here; but we must not lose sight of the fact that sporadic cases of malarial fever appearing in non-malarial districts can frequently be traced to previous exposure in an infected locality.

Malaria, although having its ordinary habitat in low-lying regions, may under conditions favorable for its production exist at great elevations. On the Tuscan Apennines it is found at a height of 1,100 feet above the sea; on the Pyrenees and Mexican Cordilleras, 5,000 feet; on the Himalayas, 6,400 feet; on the island of Ceylon, 6,500 feet; and on the Andes, 11,000 feet. Sometimes, however, at considerable elevations it is unaccountably absent under circumstances apparently supplying every condition for its development. Thus, according to Jourdanet, close to the city of Mexico lies the lake of Tescudo, some twenty-five square miles in extent, composed partly of fresh and partly of brackish water, with a clayey bottom often laid bare over large areas as the result of evaporation under a temperature of 122° to 140° Fahr., notwithstanding which, malarial fevers seldom occur in its vicinity. At Puebla, Mexico, on the other hand, is a very malarious marsh 5,000 feet above the sea. Under ordinary circumstances, a certain altitude affords immunity from malaria, although low elevations of 200 or 300 feet above a miasmatic tract are often more dangerous than the flat lands—the poison seeming to float upward and become intensified. This was long noticeable on the heights of Bergen Hill, West Hoboken, and Weehawken, which overlook the Jersey flats. At present, the elevation

of entire security is not positively determined, but it has been approximated as follows: in Italy, 400 to 500 feet; in California, 1,000 feet; along the Appalachian chain of the United States, 3,000 feet; in the West Indies, 1,400 to 1,800 feet; in India, 2,000 feet. In any of such regions, however, malaria may drift up ravines to an indefinite height. The agency of winds in transporting malaria for considerable distances cannot be questioned. Lancisi, author of the famous work "De Noxiis Paludum Effluviis," published in Rome in 1717, attributes to such influence the fact of the Roman Campagna having become unhealthy after the removal of the sacred groves exposed it to the currents of wind blowing from the Pontine Marshes. In later years, Barat accounts in the same manner for an epidemic of malarial disease which arose in 1869 on the island of Réunion, believing the poison to have been transported by the wind from Mauritius, where such affections were then alarmingly prevalent. In this instance none of the ordinary local causes could account for the outbreak. In four months, over 4,000 cases occurred in a population of 23,000. Salvagnoli and other observers affirm that malarial diseases increase in intensity, and penetrate farther inland on the island of Sicily and in South Italy during the sirocco laden with African miasm.

With regard to the question, "Can drinking-water act as a vehicle for the introduction of malaria into the animal system?" *a priori* it seems reasonable to suppose that such may be the case. If malaria, be it a gaseous substance or an accumulation of minute organisms, cannot pollute water, it differs essentially from other materials of similar form with which we are better acquainted. But, in fact, we have positive proof that malarial fevers may be due to drinking impure water. Mr. Bettington, of the Madras Civil Service, states that in that country it is notorious that the water may produce miasmatic fever and affections of the spleen. He mentions villages placed under similar conditions as to marsh-air, in some of which fevers are prevalent and in others not—the difference resulting from the former drinking marsh-water and the latter pure water. In one village there were two sources of supply—a tank fed by surface and marsh water, and a pure spring; only those who used the tank-water contracted fever. The celebrated instance related by Boudin is still more conclusive on this point. In 1834 there returned to Marseilles from Bona in the ship Argo 120 soldiers, of whom 103 were seized with various forms of malarial fever after drinking marsh-water taken on board at Bona. On the other hand, the sailors of the same vessel, who had pure water, and 780 men embarked on two other vessels, remained well. The few soldiers on the Argo not attacked had purchased their drinking-water from the sailors. Against such positive evidence as this the statement of Finke that in Hungary and Holland marsh-water is drunk without injury is of little value.

Now, a number of careful investigations have been made of the constituents of miasmatic marshes in various parts of the world, with the following results: They contain from thirty to thirty-five per cent. of vegetable organic matter. This consists of humic, ulmic, cremic, and apocremic acids, all substances requiring renewed chemical investigation. Various minute vegetable algoid forms are revealed by microscopic examination—bacteria, vibriones, and microzymes. But all these so-called impurities are found in nearly every running stream and in many harmless well-waters, and to condemn water on account of their presence would be really to reject all waters, even rain, in which minute algoid vesicles (protococci) are often found. Even distilled water may contain bacteria and vibriones. Although, therefore, admitting that water may be contaminated by the presence of malaria, it by no means follows that this poisonous ingredient has any relation to the organic impurities mentioned, or that the latter are in any way injurious, but we should none the less be cautious as to the source of our drinking-water.

The stratum of air overlying typical malarial marshes has also been examined with particular care. It has been found to contain an excess of carbonic acid—watery vapor in large quantity—often carburetted hydrogen, and occasionally free hydrogen, ammonia, and phosphuretted hydrogen. If the marsh contains sulphates, sulphuretted hydrogen is present. Its organic matter blackens sulphuric acid—gives a reddish color to nitrate of silver—has a flocculent appearance, a peculiar odor, and affords evidence of ammonia. The amount in Becchi's analysis was .000118 grain in each cubic foot of air. Ozone had no effect upon it. Besides this organic material, various vegetable and animal matters are arrested when the marsh-air is drawn through water or sulphuric acid—*débris* of plants, infusoria, insects, and even small crustacea. Dr. Balestra has described spores and sporangia of a little algoid plant in the air of the Pontine Marshes. Lemaire and Gratiolet, in 1864, found in the air of one of the most unhealthy marshes of Sologne spherical, ovoid, and fusiform spores and a large number of pale cells, products, no doubt, of vegetable putrefaction. It has been supposed, by Schönbein and others, that ozone is deficient in marsh-air; that the quantity of ozone in the atmosphere and the prevalence of malarial diseases have an inverse proportion; and that ozone, by virtue of its supposed power of destroying organic matters in the air, is an antidote to miasm. There is, however, no evidence at all that ozone and malaria are antagonistic, or bear to each other any relation whatever. These various examinations, though interesting, bring us no nearer to a solution of the question, *What is the nature of malaria?* All of the many substances and forms thus far observed in malarial localities may be found equally in districts perfectly salubrious.

That it gains access to the system principally through the respira-

tory organs is quite certain. What we really do know of it has reference more particularly to its mode of action. It is most dangerous when the sun is down, and it seems almost inert during the day. It appears providential that the same agency which is so potent in its production should be the principal instrument of its destruction. It loves the ground, where in many regions it is so concentrated and deadly as to destroy the incautious sleeper on the earth almost as quickly as the most noxious gas. Hence it is generally regarded as having a specific gravity heavier than that of air, but this is by no means certain. It is doubtless rendered heavy by combining with night-fogs and dews, but upon their being dissipated by the sun it rises into the air and probably becomes innocuous by wide diffusion and dilution. It is intercepted by impediments, such as walls and groves of leafy trees, which obstruct the winds that bear it. Perhaps the latter also neutralize it by absorption. It is likewise neutralized and probably absorbed in passing over a considerable body of water —especially salt-water. The distance necessary to effect this result naturally varies with circumstances—force of winds, concentration, intensity, and abundance of the poison itself. According to Blane, in the channel between Beveland and Walcheren, 3,000 feet of water rendered it inert. In China, three-quarters of a mile, and in the West Indies, one mile, have been required to be effectual.

Recognizing the facts mentioned, the precautions to be observed against malaria are quite obvious. In built-up cities we are protected by pavements and sewers to a great extent, and probably also by the character of the atmosphere, which is artificially warmed by radiation at night, and impregnated with gases which, though injurious in other ways, are antagonistic to malarial emanations. But in malarial suburban and country districts it is otherwise. There certain precautions are necessary. If possible, elevation of a dwelling-place, at least 500 feet above the source of the miasm, is to be recommended in temperate climates, and from 1,500 to 2,000 feet in the tropics. If this be not practicable, thorough subsoil drainage, filling up of low and moist grounds, covering the earth with closely-cut herbage, belts of umbrageous trees interposed between the dwelling and the point of danger, but at a sufficient distance to permit free ventilation, and the access of sunlight; doors and windows opening principally away from the malarial quarter; the house, if possible, to be raised on pillars or arches a few feet above the ground, otherwise a sub-cellar thoroughly cemented—all these are measures of primary importance. The sleeping-apartments should not be below the second story, and should be provided with open fireplaces in which on damp or chilly nights a little fire may be kindled. Exposure to the open air after sunset, or until several hours after sunrise, should be avoided. As whatever tends to lower the vital powers predisposes the individual to malarial invasion, personal hygiene is indispensable. It should of course be

dictated by common-sense, with the object of establishing and maintaining, in the words of the old maxim of the sanitarian, *mens sana in corpore sano.*

ROCK-STRUCTURE.

By Rev. J. MAGENS MELLO, M. A., F. G. S.

THE study of rock-structure is one of great interest to the geologist, and not only does it teach him the various materials of which any particular rock is built up, but it will often lead him to the knowledge of wonderful facts relating to its origin and past history, and will enable him to trace some of the many changes to which it may have been subjected during the lapse of time.

I propose to illustrate this by taking some familiar specimen and showing the ways in which we may investigate its nature and history.

Suppose we take a piece of granite and see what we may learn about it. There are few persons but are acquainted with this rock in some one or more of the forms in which it is found. Our public buildings often present us with splendid illustrations of granite, sometimes roughly hewed, as it has come from the quarry; in other cases highly polished. We have seen the fine gray stones from Aberdeen, or the beautiful red ones from Peterhead and elsewhere. Now, when we begin to examine a piece of one of these granites, we see at once that it is not an homogeneous stone—such, for instance, as is a bit of flint—but that it is built up of various dissimilar-looking materials; and we may notice, moreover, that one or more of those materials is crystalline, that it is shaped in some regular geometrical form. We shall probably be struck with certain whitish or flesh-colored crystals, more conspicuously prominent than the other substances of which the specimen is composed. With some care we may be able to make out in part the form of these crystals, and perhaps to measure one or more of their angles; then, too, we shall notice that these crystals are apparently imbedded in a more glassy-looking substance of a clear and grayish color, and here and there we shall observe some bright spangles of a thin flaky mineral. We shall thus have seen the three principal minerals of which typical granite rock is composed; the larger opaque crystals, whether white or pink, are feldspar, the glassy mineral is quartz, and the little glittering spangles are mica. We may next proceed to a more detailed examination of each of these in turn. We will first ask the chemist what he can tell us of their composition. The chemist is not satisfied with merely knowing that a certain mineral occurring in certain definite crystalline or other forms is quartz, another feldspar, and so on; but he asks further: "What is this quartz? Is it a simple body, or is it, simple as

it may appear to sight, a compound of two or more elements?" He takes various specimens of quartz, some perhaps from the granite, others from some other rocks, and subjects them to the analytical processes of the laboratory: the result is, that he finds all quartz, no matter what its color may be, whether white or pink or black, or pure and colorless as glass, to be a compound of the metalloid silicon and the gas oxygen; in other words, that it is an oxide of silicon, to which he assigns the name silica. By a series of analyses he is able to correlate the quartz of the granite with all other forms, and they are many in which this mineral occurs. The flint of the chalk, the white

FIG. 1.—SECTION OF GRANITE FROM CORNWALL (POLARIZED), MAGNIFIED 26 DIAMETERS.

veins so often met with in the older slaty rocks, the agates picked up on the sea-shore and elsewhere, the beautiful crystals known as cairngorms, amethysts, and others, are all found to be but varying forms of the same substance, colored sometimes by adventitious matter, as iron, etc.; and he finds, too, that the exquisite skeletons of some of the sponges, the delicate valves of the *Diatomaceæ* and other minute specimens of organic life, consist of this very same silica, which is indeed one of the most important compounds entering into the structure of the earth's crust. Suppose the student next picks out one of the feldspar-crystals: this on analysis will be, as was the quartz, found to be also a combination; in it he will also find silica, but the silica in this instance is found to be combined with the metals aluminium and potassium—in fact, is a double silicate of alumina and potash. There are many varieties of feldspar: some of them differ from that most common in granite, which is called plagioclase, in containing lime or soda instead of potash; these are also distinguished from the orthoclastic series by their crystalline structure, which will afford, as we shall see, a ready method for their recognition, when they are

microscopically examined. When the granite rocks become decomposed, as they often do in Cornwall and elsewhere, through the wear and tear of the weather, we frequently find the disintegrated materials so separated that the silicate of alumina of the feldspar forms thick deposits of the beautiful white clay known as kaolin, and which is so valuable to the china-manufacturer.

The mica of granite is usually a variety called Muscovite, or potash mica; this again on chemical analysis is found to contain, as did the feldspar, silica, alumina, and potash, and also often some iron and manganese. There are several different sorts of mica, also, sometimes found in granite, especially Biotite, the composition of which varies from the above; but all the micas may be known by their being found in flattish crystals, which may be split up into an infinity of thin leaflets. Thus far our unaided eyesight and the help of the chemist have

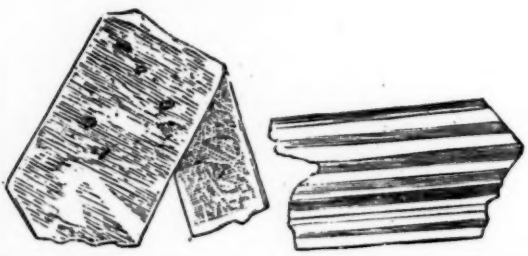


FIG. 2. ORTHOCLASE FELDSPAR. FIG. 3.—PLAGIOCLASE FELDSPAR.

shown us what granite is made of; but we are now beginning to learn that, would we know something of the real history of a rock, a far minuter examination is needful, and geologists are rapidly learning that they must turn to the microscope if they would receive answers to many important questions, both as to the history and also as to the composition of rocks. A marvelous light has been shed during the past few years on rock-structure through this minute investigation, especially with the aid of polarized light. The intricacies of the closest-grained rocks have been disentangled, their component parts distinguished from each other, and the very order and history of their combination in the mass revealed. Now, when we examine our granite beneath the microscope, which can be done by having thin slices prepared, we shall learn something about it which we could hardly hope to have discovered without this aid. There has been much speculation as to the origin of granite, whether it is a plutonic—that is, an old volcanic rock—or whether it is only a deposit from water consolidated and altered during the lapse of long ages by heat and pressure: the microscope will help us to the truth. When magnified and examined with the polariscope, a thin section of granite is a very beautiful object, and its different constituent parts stand revealed with the greatest distinctness: we at once learn to see the crystals of

feldspar, somewhat opaque and cloudy as they usually are in granite, but now and then clear and beautifully striped, and also the crystals of mica, imbedded in the clear quartz, which will be at once known by its bright clear colors and by the margin of rainbow-like tints which border its patches. Ordinary orthoclase feldspar is usually somewhat opaque and dirty-looking under the microscope, and by this it may be distinguished from the clear, glassy sanidine which is frequently found in igneous rocks, and presents under the microscope, when polarized, pure rich colors as well as sharply-defined crystals similar in form to those of the common orthoclase. The orthoclastic feldspars may be very readily distinguished from the plagioclastic by their structure, as revealed by the polariscope; the latter invariably are seen to be striped with variously-colored bands, showing what is called twin crystallization; and the orthoclase, though often forming twins on a larger scale, does not present the minutely-banded appear-

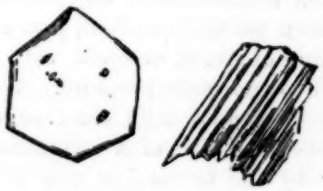


FIG. 4.—MICA (BIOTITE).

ance of the plagioclastic feldspars. The mica in the granite section will not be difficult to recognize, especially if Biotite; often we shall observe it as forming fairly-shaped hexagonal crystals, and the polariscope will also help us to know it by its thinly-laminated structure, giving rise to fine parallel striæ on the surface of its crystals. Its colors, also, when polarized will be duller than those of the quartz, for which it might sometimes be mistaken at first sight, should it be a light-colored mica; and then, again, it will frequently be found that when the prisms of the polariscope are crossed the mica becomes perfectly opaque, its sections having been formed across the optical axis. But let us now look at the quartz. We shall observe that this quartz is generally not crystallized in definite forms, as are the feldspar and the mica; it appears as a matrix which has been at some time or other soft and so is penetrated by the other crystals, the interspaces of which it fills up: this shows us at once that it must have been solidified after them, and so was unable to assume its regular forms. This is a very remarkable fact, and helps us toward the secret of the formation of the granite. We know that quartz requires a higher temperature to melt it than does either the feldspar or the mica, and so, had the granite been formed as are regular volcanic rocks in the ordinary way of igneous fusion, we should certainly have found that the quartz would have crystallized before either the feldspar or the mica, and it

would have been seen in definite crystalline form, and its crystals would have interfered with and penetrated those of the other mineral constituents of the rock. Again, if we look carefully at the quartz with a moderately high power, we shall see in it certain small cavities, and some of these will be seen to contain a certain amount of liquid, and also an air-bubble, which will move as the specimen is moved. This liquid has been proved to be water, and from the fact of its not entirely filling the cavity we learn that a reduction of temperature has taken place since the water was first caught up by the quartz, causing the contents of the cavities to contract. Sometimes we shall find other cavities, which, instead of containing water, contain small crystals, or even air only. Now, from all these facts it appears tolerably certain that the granite was formed under peculiar circumstances; it has never been such a purely molten rock as is the lava of a volcano, which is poured out from its crater to the light of day. We gather that it was rather formed at great depths in the earth, where it may have been partially melted, partially subjected to the action both of water and of steam, charged with various mineral substances, and subjected to enormous pressure. What the original condition of granite was we cannot tell; some have gone so far as to think that it may have been that of a sedimentary rock, which has been metamorphosed by the forces just alluded to. But, whatever the primary state of granite may have been, its present condition shows it to belong undoubtedly to the igneous class of rocks, but to have been formed under conditions differing from those which have given rise to lavas reaching the surface. As far as can be gathered, the granite rocks, as such, have never seen the light of day until exposed by denudation, etc.; their origin was deep in the central portions of ancient volcanoes, where, by partial melting and slow cooling, under intense pressure, and in the presence of some water, the various minerals came together and crystallized into granite.—*Science-Gossip.*

THE APOTHEOSIS OF STEAM.

By JOHN S. HITTELL.

IN a newspaper notice of a late book the critic complains that it is "an apotheosis of steam," an offense which he does not explain, but he conveys the inference that the book mentioned attributes to steam and to its age too much influence and importance in human life. He raises the question whether steam deserves apotheosis, and I answer affirmatively, undertaking to prove that, with its associate forces, it has conferred upon mankind benefits of vast, and, if considered absolutely, of unparalleled value; that the period since Watt's

machine came into use deserves to rank as the leading era in history; and that it demands from us more study than either of the preceding ages of the press, iron, bronze, or stone, though they lasted much longer and have heretofore occupied much greater prominence in historical study.

Modern civilization belongs to the Euraryan—the Teutonic, Latin, Celtic, Slavonic and Greek—nationalities which migrated from Asia in the remote past to Europe, whence some of them passed over to other parts of the world, carrying their culture, their energy, and their high capacity for further progress, with them. The Asiatics, the Africans, and the aboriginal Americans and Polynesians, have for the last four centuries acted a part so subordinate in the great drama of human advancement, that they are like the shadows of a picture; they serve mainly as contrasts to bring out the brilliancy of the forms and colors in the light.

The age of steam—the period between 1770 and 1875—has trebled the Euraryans who have given us the enlightenment of the present, and are the hope of the future. Their number a hundred years ago was probably 120,000,000; though Gibbon, in the sixty-second note to the second chapter of his "Decline and Fall," following Voltaire, who was a respectable authority, said that Europe then had 107,000,000 inhabitants, including twenty-two in Germany, twenty in France, twelve in Russia, ten in Italy, eight in Spain and Portugal, eight in Great Britain and Ireland, seven in Scandinavia, as many more in Turkey, and four each in Hungary and the Netherlands. The facilities for getting information then were not so good as now, and, though Gibbon was very careful in his statements, yet he probably made a mistake in his figures. Kolb, in his "Hand-book of Comparative Statistics" (German, and not translated), tells us that France had 22,500,000 in 1770, Spain nine and one-third in 1768, Germany thirty in 1786, and Italy twenty in 1812; and Levi, in his "History of British Commerce," credits Great Britain and Ireland with ten in 1763. After excluding certain nationalities not of Aryan blood in Europe, and adding the British and Spanish colonists in America, we may estimate the total number of Euraryans in 1770 at 120,000,000. The present number is about 360,000,000, including three hundred in Europe, and forty-eight in North America. This great increase, far from being a necessary or natural result of the lapse of time, is entirely unexampled. The Roman Empire had about 120,000,000 inhabitants, and the same territory after a lapse of eighteen centuries had no more. Egypt 3,000 years ago, and Peru and Mexico before the Spanish conquest, had more inhabitants than now. As a general rule, population has been nearly stationary; century after century has passed, with little difference until we come within the magic influence of steam, and then suddenly the Euraryan race, acquiring the power to draw larger crops from the soil, to distribute

them more evenly, thus preventing disease and famine, and to visit new and more profitable fields of industry, multiplies so as to keep pace with the increased supplies of food and with the demand for labor.

Education, like civilization, of which it is a large part, belongs mainly to the Euraryans. It is the misfortune of the Chinese and Japanese that more time is required to learn their hieroglyphical writing than to get a liberal education in a Teutonic or Latin tongue. The Arabs and Hindoos have alphabets, but they have no eminent schools, no rich literature, no great city in which their race has reached a leading place in culture. The possession of the alphabet, with the books, the schools, the wealth, and the centres of civilization, in the temperate zone, where man has the strongest stimulus and the most energy for the exercise of his physical and mental faculties, gives to Euraryans the mastery of the fortunes, and almost a monopoly of the interest of earth. Progress depends not so much on the number of those who come within its nominal domain, as of those who are under its full influence and appreciate its value; that is, the educated people. They have increased ninefold since 1770. In that year not one out of a hundred adults in Russia and Turkey, not ten in Catholic Europe, not thirty in Protestant Europe, could read. Now, about eighty-five out of a hundred in the Teutonic, and fifty in the Latin nations, can read, or nearly 200,000,000 in all. The gain in education is, however, much more than that indicated in the mere increase of those able to read. The quality of the learning has improved as much as its quantity. In the middle of the last century, there were few books worth reading in any modern language. A man was not accounted well educated unless he were familiar with Latin. So scanty were the literatures of French, English and German, that they were considered unworthy of the notice of scholars. The student had to read Greek and Latin to learn "the humanities." There was no science save dry astronomy and mathematics, little history, little philosophy, little poetry. The chemistry, geology, and physiology, which form the bulk of our positive knowledge, are products of the steam age; and, instead of being dry and remote from the business and associations of practical life, they come home to us every day, guarding our health, assisting our industry, and influencing our opinions. Ancient Egypt, Assyria, and Hindostan, and the prehistoric man in Europe, have been made known to us by late research, and even our histories of Greece and Rome have required rewriting, to adapt them to the advance of our knowledge and philosophy.

A large majority of our most instructive books are the product of the last hundred years. Of the works sold in the book-stores or loaned by the public libraries, at least ninety-five per cent. are new. Nearly all our prose romance, and most of our poetry, history, and miscellaneous literature, belong to the steam age in origin and spirit. We now write ten times as many books, and publish fifty times as many vol-

umes annually, as they did in the last century. The United States turns out 2,000 and Great Britain 4,000 new books every year, and the other Euraryan nations probably bring the total figure up to 15,000; whereas, before the middle of the last century, the number was probably not more than 1,500. Besides the books, we have now 7,000 newspapers which are new, and in the aggregate furnish as much material for reading, and contribute nearly as much to education, as the books.

The commerce of the world has been revolutionized in the age of steam. Many obstacles which stood in the way of its development in 1770 have now been removed. National animosities, sectarian passions, popular ignorance, despotic governments, the division of one nationality into numerous independent states, and the established policies of conquest, balance of power, sectarian intolerance, and trade-restriction bred frequent wars, and destroyed confidence in the duration of any peace. Hostilities were waged with little regard for the property or persons of non-combatants; and plunder and devastation were among the common accompaniments of invasion, and were recognized as customary rights of the invaders. The uncertainty of enjoying accumulated wealth deprived the people of zeal for labor or economy. But now there has been a vast change for the better, and commerce and finance have made wonderful advances. International and national traffic have risen to proportions which far surpass the wildest visions of past ages.

In the middle of the last century a turnpike, covered with gravel or broken stone, was a rarity even in the neighborhood of the great capitals; and for every mile of such road, and for every stage running regularly to carry passengers then, there are now a thousand. Travelers were few, and usually went on horseback. Not a hundred years have elapsed since the owners of riding-horses petitioned the English Parliament to forbid the establishment of a stage-line which had lately been started, and was ruining their business. In 1763 one stage left London for Edinburgh each month, taking nearly two weeks to make the trip each way; and in 1810 only two hundred and twenty travelers entered Paris by stage in an average day. The increase has exceeded a thousand-fold. England did not commence building canals till 1760, and in the mean time not less than 6,000 miles have been built by the Euraryans, at a cost of not less than $500,000,000. The shipping of Christendom has risen from 1,500,000 to 15,000,000 tons, and a third of the increase is in steamers, which make three trips for one by a sailing-vessel. They not only carry three times as much freight per ton as the sailers, but they take many perishable articles which could not go by the slower navigation, and were therefore not produced, or were wasted. There has been a vast increase in the construction and in the number of freight-wagons for common roads; and the railroads, with an aggregate length of 140,000 miles, and a cost of $2,000,000,000, are new. The freight which cost thirty cents a

ton from London to Manchester in 1825 now costs one cent. Counting the macadamized roads, the new and improved wagons, the canals, the river and ocean steamboats, the increase in the number, and the improvements in the size, pattern, rigging, and speed of sailing-vessels, and the railroads, there is no exaggeration in saying that the facilities for domestic and foreign commerce have increased one hundred-fold.

And then the gain in the materials for commerce has been immense. Steam-engines furnish a power estimated to be equal to that of 300,000,000 working-men, and the saving of labor by other machines is probably not less. The production of cloth and the manufacture of iron have been revolutionized, and the annual consumption of the most useful of metals has increased from 200,000 to 12,000,000 tons. The industrial arts generally have made so much progress, that no extensive branch of business is now conducted as it was in the middle of the last century. Our houses, our tools, our clothing, our food, our trades, and our professions, are different in many important points. The farmers have thrown aside the wooden plough, the sickle, and the flail, which were their chief implements in 1750. The wooden mould-board was excellent as compared with the barbaric plough which had no mould-board, and did not throw a furrow to one side, but merely scratched the ground, making a ridge on each side of the plough-point. While oak was the material, the farmer usually hewed or chopped out his own board, and fastened it on his plough; but both the shape and the adjustment were bad, and the surface, from the nature of the material, would never "scour" well in the moist earth. I accord to Scotland, on what appears to be a preponderance of evidence, the credit of producing the first iron mould-board, though the claim is contested by the United States, where the invention was first generally appreciated, and perfected by various small improvements. The superiority of the iron plough in form, adjustment, and surface, made a vast saving in friction; the furrow was turned over more regularly; the weeds were killed more thoroughly; the pulverization was better; and the working capacity of the ploughman and the productive capacity of the soil were each nearly if not quite doubled; so that now, France, with a smaller number of men engaged in the business, yields three times as much wheat at an average harvest as it did about 1770. Since the farmers are the largest class of producers, and the basis of national prosperity, and since ploughing is the most important part of their labor, the invention of the iron mould-board deserves to be considered one of the greatest contributions to modern civilization, ranking next to the steam-engine and to movable type, in its influence on the general condition of mankind.

The sickle was superseded by the cradle, with which the farmer could cut four times as much, and that by the reaping-machine, with which a man can cut five times as much, as with the cradle. The scythe gave way to the mowing-machine, and the flail to the thrash-

ing-machine. The steam-plough has not yet been introduced extensively, but it will doubtless make another revolution. The progress made in the drainage of land by pipes, in the drying of fruits and vegetables by hot air, and the canning of fruits and meats, all are important aids to agricultural industry. The breeds of farm-animals have been greatly improved. The Ayrshire, the Durham, the Jersey, and the Devon, the Cotswold, the Southdown and the Cheviot, the Chester and the Berkshire, the Clydesdale and the American trotter, have been either started, or for the first time introduced into extensive use, in the steam age.

The miner has adopted dynamite and other explosives stronger and safer to handle than the charcoal-powder, and can, at the same time, hold and strike the small drill, whereas the large drill needed for the weaker powder required one man to hold the drill while another was striking. Steam not only hoists the ore and pumps the water, but sometimes drills the rock. The method of stoping toward the shaft has been introduced. More important still is the general education of the superintendents in engineering and chemistry. The processes of separating gold and silver from the earthy and rocky matter which hold them in a state of nature are new in their principal features.

All the prominent mechanical occupations have felt the influences of our progressive time, and many have been added to the list. Nearly every labor-saving machine has called a new trade into existence. The builders of stationary engines, of locomotives and of railway-cars, the boiler-maker, the steam, the railway, and the gas engineers, the gas-fitter, and the manufacturer of chemicals, are a few out of many. Planing and moulding machines, and circular and band saws, wire ropes and iron bridges, "balloon" house-frames, fastened together with nails, and without the old style of mortices and tenons, and machines to make cut-nails and wood screws, have had much influence in mechanical business. If steel pens had not come into use as a substitute for quills, the supply of which would have been entirely inadequate to the scribbling demands of the present day, education might have felt a check. The steam-press, the turbine-wheel, the type-casting machine, lamp-chimneys which secure better light with less smoke, kerosene-lamps, cleanly stearine-candles instead of the dirty tallow, are all to be credited to the steam age.

The railroads and the steamboats have covered the land, the rivers, and the lakes of Europe and North America with the beneficent network of their routes, and have given a new life to commerce. The exports of Great Britain in 1770 amounted to $65,000,000, and in 1870 to $1,220,000,000. In the same period the measurement of the shipping owned in that country increased from 550,000 to 7,100,000 tons, and that of the shipping entered in a year from 890,000 to 18,000,000 tons. The amount insured rose from $850,000,000 to $6,800,000,000.

The greater part of the increase in commerce since 1770 has occurred within the last fifteen years, and the annual gain now is greater than the total traffic in the middle of the last century, and tenfold greater than the traffic at any time before the discovery of America.

The advance in the other nations of Europe generally has not been so rapid as in England, yet it is remarkable. The exports of France rose from $400,000,000 in 1840, to $700,000,000 in 1869; those of Austria from $40,000,000 in 1842, to $160,000,000 in 1869; and those of Russia from $50,000,000 in 1851, to $125,000,000 in 1869. In the United States the progress has been more rapid than in England. The total aggregate value of the exports and imports (excluding the precious metals) of the fifteen leading commercial nations was $6,000,000,000 in 1860, and $9,500,000,000 in 1870. These figures are astounding, and nothing but figures can give us a correct idea of the overwhelming magnitude of the present, and the relative insignificance of the past. And if now commerce gains nine per cent. annually, whereas before the steam age it did not increase one per cent., shall we not exalt the age of steam, which has brought the improvement? It is to be observed that the forces which have caused the wondrous development, instead of having reached the culmination of their influence, are only beginning to get full swing, and that the new commerce has not yet had time to exert its power. Statesmen and people do not yet comprehend the vastness of the commercial interests, nor have the merchants and capitalists yet learned how to combine to prevent the legislative follies of past ages. Commerce is destined to be the great bond of peace between nations, and they will be compelled soon to organize a league to administer international justice, and to protect the vast interests involved in their trade. They must adopt new rules for their new circumstances. The policy which might have been beneficial in a national point of view in 1700 would be foolish now. "Commerce," as John Stuart Mill said, "first taught nations to see with good-will the wealth and prosperity of one another. Before, the patriot, unless sufficiently advanced in culture to feel the world his country, wished all countries weak and poor and ill-governed, but his own." Now, he understands that the greater their wealth and prosperity, the greater also will be that of his nation; in the same manner as the individual merchant or mechanic thrives better with rich than with poor neighbors and customers. But we are told that the spirit of our age is bad; it is too materialistic; it is hostile to æsthetical and spiritual influences; it exalts money and machinery. The meaning of this complaint is that its authors have not been properly educated, and they find that the world is not in sympathy with them. They measure it by their ignorance and prejudice, and conclude that it is wrong. In all ages such lamentations have been heard about the progress of the most beneficent changes. The discredit into which many of the old metaphysicians have fallen is

chargeable in a great degree to our superior knowledge. We have discovered that their premises were false, and of course we care nothing for their conclusions. I assert that poetry, painting, sculpture, and architecture, never within an equal period produced so many great works as since 1770, but I have not here the space to argue that point.

I think the proof is sufficient that there has been an immense change in human life for the better since the middle of the last century—a change great enough to require the recognition of a new era in culture. The preponderant influence and characteristic of our time suggest that it should be called "The Age of Steam;" and this, like the universally-accepted stone, bronze, and iron ages, suggests that industry is the most important feature of culture. No other name has been offered, no other force can compete with it. The improvements in printing and in the manufacture of iron and cloth, great as they are, are yet dependent for much of their value on the steam which drives the press, the rolling-mill, and the loom, and transports their products to market. The electric telegraph is inferior to either of these three: Watt's invention remains master of the field. It has made a new era, which ranks with that of bronze, and the two surpass in importance all the others.

When savages learned to make bronze, their former weapons and tools of stone and bone were thrown away. The flint knife, which lost its brittle edge at the first cut into wood, was replaced by tough metal which could be sharpened anew every day, and would last for years. The clumsy obsidian spear-head, that flew to pieces at the first throw, was superseded by another of better shape and more durable material, fitted for the wear of centuries. The savage armed with flint weapons was no match for the man of bronze, and thus the latter could take the most fertile valleys and reduce the former to slavery. The possession of metallic hoes, spades, and sickles, was the beginning of systematic agriculture. The soil began to produce abundantly; the supply of food was larger and more constant; population became dense; buildings of cut stone were erected for temples, fortifications, and granaries; the accumulation of property became possible and reputable; nations were organized and armies drilled. All these changes were the necessary results of the discovery of the art of making bronze. Previously men were in the stone age, without durable houses, without national government, without cities, without any accumulation of property, division of labor, literature, or prospect of progress.

The iron and printing ages made revolutions in society, but they were far less important than those of bronze and steam. The bronze revolution was the greater, looked at from a relative standpoint, but, considered absolutely, it was small in comparison, and very slow in progress, with the influence of steam. The ancient Egyptians asserted

that their monarchy had stood without material change for 10,000 years. There is much reason for believing that their religion and polity were about the same for at least 3,000 years, and for presuming that they must have been very slow in reaching that condition. The farther we look back into history, the longer we find the intervals between the permanent improvements of culture. The present age is resplendent not less for the magnitude of its inventions and discoveries than for the speed with which they have crowded upon one another's heels, and have been carried round the world. No previous time has approached ours in its achievements, and, if ever any force of culture deserved apotheosis, it is steam.

ON THE BACKWARDNESS OF THE ANCIENTS IN NATURAL SCIENCE.

By CARL VON LITTROW.[1]

I CAN hardly be mistaken in holding that the ceremonies attending the installation of a rector of our university chiefly concern the students. Thus only can I account for the fact that on the one hand the newly-installed officer is burdened with the unpleasant duty of listening to a history of his own life, and, on the other, that he is required to deliver an address whose sole purpose is to make known the ground he occupies in science and in his teaching. His colleagues, to whom he is indebted for his election, of course have no need to be informed where he stands, while the students oftentimes have but scant opportunity of knowing what manner of opinions are held by him. Hence it is that my words are addressed first of all to you, my young friends.

Those nations of antiquity which so long freely and unchallenged have borne the title of "classical," owe to their mastery of form whatever right they have to that honorable epithet. While we must regard our predecessors in culture as being the best patterns in all that regards form, we may nevertheless of ourselves assert that in the investigation of matter, and in the arts of making it subservient to man, we in turn equally or even to a greater degree surpass the ancients. This condition of things is indeed nothing but one phase of the strife between the real and the ideal—a strife which, fortunately for mankind, is never altogether allayed. That in nearly every department of art—taking this term in its widest sense—we are on the whole the miserable Epigoni of the ancients, is universally admitted,

[1] Inaugural Address on his installation as Rector of the University of Vienna. Translated by J. Fitzgerald, A. M.

and the causes of our inferiority are well enough understood. On the contrary, the reasons of our own preëminence in the exact sciences are by no means so generally known. Schiller, who, had he not been a profound philosopher, would never have been the prince of poets that he was, describes the realist as being characterized by a spirit of "sober observation," and the idealist by a spirit of "restless speculation." "When we presume," says he, "by the mere force of reason to determine anything about the outer world, we do but trifle." However obvious the meaning of this remark may at first appear, we shall find, on closer consideration, that in fact the author not only ascribes to the idealistic mind of antiquity an undue bent toward speculation, but that furthermore he plainly denies to it the faculty of correct observation. The entire justice of Schiller's remark, whether as taken in its literal or in its implicative sense, is perhaps nowhere so patent as in the province of astronomy.

Every one knows of the clear skies which canopy the homes of the early civilizations—Italy, Greece, Spain, Egypt, Arabia. The purity of the atmosphere enjoyed by these regions is shown by the importance attached by the ancients to the knowledge of the rising and setting of certain stars. In our countries astronomy must have been precluded from taking the same direction by the fact that but rarely do we see the stars near the horizon, to say nothing of seeing them on the horizon, owing to the presence of haze, which in these regions nearly always narrows the field of view. For this reason, had we not the telescope, we should have been unable to attain to the comparatively accurate knowledge possessed by the ancients with regard to the movements of Mercury, a planet which is hardly visible from our latitudes We inhabitants of Central Europe might easily, in point of cloudy skies, be the rivals of the dwellers on the shores of the Sea of Azof—the Cimmerians of the ancients. It might therefore be supposed that the starry heavens, as these ancestors would describe them to us, must be in great part invisible to us, and far richer than we have been able to see them in later times. We must the more expect them to describe things hardly visible to us as our present division of the northern heavens into constellations dates, as far as its main features are concerned, from at least 2,000 years ago, and the firmament formed an object of studious contemplation even then. Add to this the fact that, as early as the year 130 B. C., Hipparchus began to draw up a complete catalogue of all the fixed stars; and Claudius Ptolemæus, 150 years later, took up this task anew. Now the "Almagest," as Ptolemy's work is called by the Arabs, who handed it down to us, includes 1,028 stars; and even if, on the strength of a remark made by the elder Pliny, who speaks of 1,600 observed stars, we with faint probability grant that the "Almagest" does not represent the complete labors of Hipparchus and Ptolemy, still even the second figure is far less than we should have expected. Argelan-

der, at Bonn, sets down in his charts no less than 3,256 stars visible to the naked eye; and Heis, whose eye indeed was possessed of an abnormal power, seeing stars as points without rays, increased Argelander's list by 2,000 stars visible at Münster. Thus, not taking into the account the no less than twenty more degrees of the heavens visible from Alexandria than from Germany, the ancients noted hardly one-half of the stars which were visible to them! The defectiveness of their observations can be more easily understood from the fact that for instance they reckoned 474 stars of the fourth magnitude, only 271 of the fifth, and finally only 49 of the sixth magnitude; whereas the fact is, that the number of stars increases so rapidly in the order of magnitudes that each succeeding class embraces a much larger number than all the classes that precede it. In our latitudes Argelander makes out with the naked eye nineteen nebulæ and star-clusters, while Hipparchus mentions only two, and Ptolemy five, neither of them noting such prominent objects as the nebula in Orion and that in Andromeda. And such defective knowledge as this of the open-lying heavens persisted long after the invention of the telescope—for full 1,500 years. Among the old astronomers the Persian, Abdalrahman-Al-Sûfi, who lived in the tenth century, forms a notable exception; but he did not inspire his contemporaries or his successors with his own ardor, or prompt them to add to his labors.

The same is to be said of the southern heavens. The Arabians, surely, did not lack opportunity for acquiring a knowledge of many of its constellations. Ever since the days of Bartolomeo Diaz, it was a necessity for Europeans, on sea-voyages, to determine places by southern constellations. Ptolemy was acquainted with only a few of the principal stars of the antarctic hemisphere, and it was not till the beginning of the seventeenth century that Theodor von Emden regularly divided these regions of the heavens into constellations. It remained for Herschel, in recent times, to determine a number of open questions with regard to these southern constellations.

To account for this backwardness in the investigation of a subject which certainly possessed at least as much interest for the ancients as for ourselves, by declaring it to be the result of their superficiality, were an injustice to the olden time, seeing that in other respects it commands our unconditional admiration for its arduous achievements. That what they needed was to have their senses trained to this kind of work, and that, although they had keen appreciation of art, they never learned to look at things with the eye of the investigator of Nature, will be better understood from a statement of what they knew about individual celestial objects than of what they knew about the entire firmament.

That well-known group of stars, the Pleiades, which in the Fall adorns our eastern sky by night, serves well to show that in observing the stars something else is required besides a clear atmosphere and

good eyesight. In a didactic poem by Aratus, written 270 years B. C., we have our earliest trustworthy account of Grecian astronomy. There the Pleiades are called "*ἑπταπόροι*"—*stars traveling in seven paths*—though according to Aratus only six stars were visible. Some 300 years later Ovid writes—

"Quæ septem dici, sex tamen esse solent;"[1]

while Hipparchus, in his critique of Aratus, about 150 years before Ovid, expressly says that in clear, moonless nights seven stars can be actually made out. Now, Aratus lived in Macedonia, and Ovid apparently wrote his "Fasti" at Rome, giving the finishing touches to the work on the southern shore of the Black Sea: thus both writers lived beneath a very clear sky. The fact that Hipparchus labored at Rhodes, a few degrees farther south, must not be supposed to account for his having seen one more star than the others, though the discrepancy between the observers is all the more surprising as the group about which they differed was of great importance for navigators in the then state of nautical science, and was constantly under observation. This circumstance, in fact, attracted the attention of the astronomers of the time, but for centuries they sought in vain for the seventh star, and offered all manner of curious explanations for its supposed disappearance, one of which is worthy of special mention, viz.: that this seventh star had moved over to the position of the middle star in the tail of Ursa Major, called by the Arabians Mizar, and that it was the little star now commonly known as the Postilion and which stands close to Mizar. The scholia to Homer cling to this idea of the disappearance of the seventh star. Not until the thirteenth century do we find a correct description of the Pleiades, in a work by the Persian astronomer Kazvini, who apparently borrowed it from Sûfi. "There are," says Kazvini, "six stars (in the Pleiades) and in the midst of them a number of dark (i. e., faint) stars;" but his observations received no attention from subsequent astronomers. In vain, too, was the observation even of such a man as Maestlin, Kepler's preceptor, who distinguished no less than fourteen stars in the Pleiades group. Not till after the invention of the telescope could Sir Christopher Heyden, in 1610, write as follows, showing the power of the new instrument: "I see with my telescope eleven stars in the Pleiades, though never before were more than seven distinguished." But how stands the case to-day? At present they who discern these eleven stars with the naked eye are considered anything but prodigies; indeed, I am acquainted with persons—not professional astronomers, but laymen—who can make out from fourteen to sixteen stars in this group. But then we are the descendants of generations of men who from infancy were taught to put their organs of sense to the sternest test, and to take note even of the faintest sense-impressions; our eyes have been schooled, and

[1] Said to be seven, though they number only six.

in this special instance of the Pleiades they are not so much dazzled by the brighter stars as guided by them to the stars in their neighborhood, for, in fact, more than one half of the fourteen stars are of a magnitude far below the commonly-accepted limit of vision for the naked eye. We have learned to observe, to choose favorable conditions, to know what is a really clear atmosphere; we know that small stars in the vicinity of bright ones are far more readily descried in twilight than in the depth of night, the brightness of the larger stars in the latter case obscuring the smaller. Hipparchus errs in saying that moonlight is a hinderance to such observation: keen eyes may, with a bright full moon shining, count as many as fifteen stars in the Pleiades.

Another point of considerable interest we note in this instructive example. The fact that the Postilion, the Alcor of the Arabians, was taken to be the lost seventh star of the Pleiades, further shows that Alcor, though a star of the fifth magnitude, and easily discernible, had not been noted by previous astronomers, else it could never have passed, at the beginning of our era, as a new star, then first registered. And indeed the Arabian astronomers, one thousand years later, call this star "The Forgotten," plainly because it had not been noticed previously.

We have a like instance in the star Alpha in Capricorn. Mankind had to observe this star for thousands of years before they saw, what any child may see when its attention is directed to the object, that here are two stars (one of the third and one of the fourth magnitude) so close together as to coalesce into one when hastily viewed. Again, it was the Arabians who noted this circumstance. Still, this did not avail to establish the true nature of *a* Capricorni. Ulugh Beigh, in the fifteenth century, and Tycho Brahe, in the beginning of the seventeenth, in their famous "Catalogues of the Stars," take no notice of it, and it was not till one hundred years later that Hevelius formally entered the companion-star in his list. We cite two or three further instances to show how the idealistic bias of the ancients, which culminated in Aristotelism, has almost down to our own times diverted men from simple but correct views of the world of sense.

The amazing progress of observational astronomy during the last two centuries is in great measure due to the happy accident of our hemisphere containing a bright polar star. Sundry investigations can be made only with regard to stars near the pole, and all the more easily, of course, and with smaller instruments, the larger the star happens to be. The importance of this star impressed itself upon men in former times, it being employed for correcting the compass. And yet even Columbus was not clear whether Polaris is situated at the north-pole, or only near to it, though it must be observed that in his day its distance from the pole amouted to more than three degrees, i. e., about six diameters of the full moon, and that hence it could

not altogether escape his means of observation. "It appears," he cautiously observes, "as if the pole-star had a motion [round the pole] like the rest of the stars."

Again, is it not amazing that for thousands of years mankind should have been in presence of so frequent a phenomenon as the zodiacal light—a phenomenon which in southern latitudes is specially impressive—without considering it to be worthy of mention, or rather, let us say, without *seeing* it, until Childrey, in the middle of the seventeenth century, *discovered* it, if we may so speak? So, too, may it excite our wonder, to think that the earliest definite mention of the noteworthy phenomena (easily visible with the naked eye) attending a total eclipse of the sun dates only from the year 1706, that is to say, a period of time full one hundred years subsequent to the invention of the telescope.

Thus the ancients were deficient in even the most elementary powers of observation. The simple but truthful noting of what is perceived by the senses is the prerogative of our time. But what of the restless spirit of speculation with which Schiller taxes the ancients?

Here permit me to recall anew to your memories, by an instance taken from the history of astronomy, thoughts which oftentimes, perhaps, have occurred to us all. Plutarch's dialogue on "The Visage that is seen in the Moon's Disk" has ever been regarded as containing the sum and substance of all man's notions and knowledge of our satellite down to the period when it was written. The very title is provocative of mirth to us, the children of the modern time. The Visage in the Moon! Nowadays it only suggests to the poet and the artist satirical ideas: in olden times it was the starting-point of profound meditations, which were held not to be unworthy of being attributed to the most famous philosophers and mathematicians of the day. The author first in all earnestness demonstrates the absurdity of the opinion which asserts the figure appearing in the moon to be nothing else but an optical illusion arising from the visual sense being dazzled by the brightness of the moon's disk. Next we have a lengthy refutation of another opinion, which says that the visage in the moon is the reflection of our ocean. Among other reasons given to show the erroneousness of this opinion is this, that there is only one ocean, and that, if the visage in the moon were a reflection of it, then the ocean must be made up of parts separated from one another by isthmuses and continents! The third opinion combated by Plutarch is to the effect that the moon is a mixture of air and of a mild kind of fire; as sometimes during a perfect calm the surface of a body of water becomes ruffled—a thing itself to be demonstrated—so too does the air assume a blackish color: thus is explained the appearance as of a human face in the moon. The hypothesis of the Stoics, who affirmed the moon to be a globe of fire, on the surface of which rests

the atmosphere, is rejected on the ground that in that case the moon would need some matter whereon to rest, and from which it might derive fuel for its fire. We are informed that, according to Pindar, the earth is propped up all round by pillars with bases of adamant, whereas, according to the Stoics, she has no need of supports, being situate in the centre of the universe toward which all things tend. This last opinion is declared to be untenable, because the earth, whose surface is so broken with elevations and depressions, must then be considered as spherical, and that would imply the existence of antipodes clambering up and down the earth's sides like lizards. Coming back to the principal question under discussion, the solitary interlocutor in this dialogue maintains that, even granting the impossibility of ponderous, earth-like bodies moving in the heavens, it does not follow thence that the moon is not another earth, but only that it happens to be in a region to which it does not by its nature belong. Man, for example, in like manner has his ponderous, earth-like parts in the upper region of his body, in the head, and the warm, fire-like parts in the lower; of his teeth some are directed downward, others upward, but in neither is there anything contrary to Nature. The moon, situate between the sun and the earth, as the liver or other soft viscus lies between the heart and the stomach, transmits heat from the upper regions to us, at the same time dissipating the mists which rise from the earth, purifying and attenuating them by the action of her own heat. Considered as an earth, the moon is a splendid body; as a star it would be a shame to its class; for of all the innumerable heavenly bodies—to quote the author literally—she is the only one that needs another's light! When the sun goes down he is hidden from us by the earth; in an eclipse, on the contrary, by the moon. Hence the earth, owing to its great size, covers the sun entirely, as long as the night endures, while the moon sometimes conceals him totally, but only for a short time. The moon, therefore, is a body like our earth; and inasmuch as it contains nothing that is foul, and enjoys the purest light of heaven, and is filled with genial fires which do not consume like the fires of earth, the moon must contain the most delightful savannas, flames like mountains of light, empurpled zones, and abundance of gold and silver; all this—accounts for the visage in the moon's disk! The objection that the spots on the moon are too large to be thus accounted for is met with the noteworthy proposition that it is the remoteness of the light from the body casting the shadow, and not the size of the body, that makes a shadow large; and if Mount Athos casts a shadow 700 stadia in length, that is a consequence not of its height, but of the sun's great distance. The discussion here is diverted to the question of the habitability of the moon and the fate of our souls after death; of this argument I need only quote the comforting assurance that the devout and the virtuous migrate to the moon, and that from the ether in which they float

they acquire an elasticity and a strength, for the maintenance of which the most attenuated vapor affords sufficient nourishment.

However incomplete this summary of Plutarch's voluminous tractate, it will serve to convey some idea of the state of astronomy and physics among the Greeks. In it we look in vain for simple recognition of the facts, or for any just apprehension even of the most elementary principles. Approaching their inquiries with foregone conclusions, they had decided the causes of phenomena long before they came fairly within range of them.

The point therefore is, not merely *what* we see, but also *how* we see; we must be able to critically examine what we have seen, and, above all, we must be able to recognize those features of the object which are of importance. And, as in the foregoing examples we have shown that in the domain of science *mere seeing* was not the strong point of the ancients, so it can be proved that they were even less distinguished for *reflex seeing*. By way of antithesis to a generally-received proverb, we may with more justice, though less poetry, declare that the simplicity of the child's understanding dwells on what is unimportant, but commonly passes by unnoticed what is really of moment. The senses, it is true, supply the material—the conscious, or mediate substructure—for the grandest systems of thought; but yet in their further development they must be subject to the action of the culture to which they themselves gave rise. Though at first they were our preceptors, now they are oftentimes our pupils. In seeing we have, perhaps, more need of the understanding than of the eye, just as in walking we could better dispense with strong legs than with sound lungs. The disciplined eye, though of feeble power, descries more objects difficult to be discerned than the strong but unpractised organ. This is true of the microscope and telescope as well as of the naked eye; and the student of Nature to-day, even with the imperfect instruments of his predecessors, sees much more than they. Who is there that has not innumerable times had experience of the dependence of the senses on the understanding, in the fact that, when he is intent on seeing a definite object, his eye becomes almost insensible to all other objects? Thus, one who is searching in a garden for red berries is quite unconscious of the blue berries which stand side by side with the red.

We have in German a term which very happily expresses the faculty, possessed by the most eminent of scientific geniuses, of discovering the important phases of ordinary phenomena: such men are said to have "Blick." Have we not an instance of a higher visual faculty, exalted not only by genius, but also by comprehensive knowledge, when a Gauss was led by the glistening of the windows of a church-tower which he was observing with his telescope to the idea of his heliotrope—an instrument without which no accurate triangulation is nowadays ever thought of; or when a Rittenhouse, in the

pretty images seen in a reversed telescope, discovered a means—ever since universally employed—of producing artificial signals which have precisely the same properties as though they stood in infinite distance; or when a Newton made of the spectrum, a thing that had been gaped at as a mere curiosity a thousand times before, the foundation of modern optics?

The sudden arrival at a truth from all sides—a thing so frequent in the history of the sciences, which often makes it hard to decide to whom the honor of new discoveries properly belongs—of itself shows that cultivated minds in general have grasped the idea. The human race might be compared to a traveler in unexplored countries. As the booty he brings home is rich in proportion to the extent of his own intellectual acquirements, which enable him to distinguish what is new from what is hackneyed, so mankind has need of schooling in order to understand what is of importance in the events occurring round about. In short, one must be impressible in order to be impressed.

Ever since the fourth century of our era, the Chinese have used the magnetic needle as a nautical instrument, and thus were enabled to extend their voyages as far as India and Eastern Africa. The Arabians brought us into relations with India in the eighth century, and the Crusaders with the Orient in the tenth, and yet the mariner's compass was not introduced into Europe till the twelfth century.

Does it not seem wellnigh incredible that we cannot trace the use of the free-hanging plummet, as a means of observation, farther back than the period when the Arabians were our teachers in astronomy; nay, that only in the fifteenth century it found general acceptance by the exertions of our renowned countryman Georg von Peuerbach?

When, at the beginning of the last century, Amontons worked with entire success an optical telegraph; and Franklin, fifty years later, robbed the clouds of their lightning; and when both of these men were dismissed even by a learned body like the Paris Academy with stale witticisms; if for thousands of years countless aërolites have been seen to fall to the earth without ever giving rise to an inquiry as to the nature of meteors—the reason is always to be found in the self-same indisposition to receive what is new, which caused mediæval Europe to pass by unnoticed the golden teachings of a Roger Bacon or of a Leonardo da Vinci. Both of these stood high above Francis Bacon as inductive philosophers; but he had for his contemporaries men who had been taught by Copernicus, Galileo, Kepler, and others, some of the mighty consequences of that principle which Francis Bacon had now simply to formulate in order to have it universally accepted. Here and there other eminent men had, long before Roger Bacon himself, hit on the right way of investigating Nature. This assertion, too, rests on unquestionable evidence, which, however, is perhaps not so familiar to you. The visibility of

the crescent moon after new moon is of ritual significance to the Jews, the ecclesiastical commencement of their months depending upon it. Their great philosopher, Maimonides, who wrote in the twelfth century, informs us of the process whereby they for a long time noted the moments wherein the lunula became visible; hence they deduced a formula by the aid of which the time of the visibility of the crescent may be calculated. This is induction pure and simple; but not till long afterward was the soil fitted to receive such seed, or the significance of this process recognized.

For only a little over a hundred years have we been following the right path. We have enlarged the capacities of our organs to an extraordinary degree; we have learned to warn our senses of the veils with which preconceived philosophical ideas were wont to blindfold them; we prize the good-fortune which places in our hands any important clew to the working of Nature; disdainful skepticism, of which Alexander von Humboldt says that, in individual instances, it is almost more harmful than unquestioning credulousness, is like the latter disappearing from among us. But we must guard against the error of supposing that herein is our entire salvation. "The educated man is more than a virtuoso, than a specialist; his power does not lie in the exercise of one faculty alone. . . . The man who harmoniously combines within himself the largest number of diverse faculties is a leader of men, though he be surpassed by others in the development of individual faculties. Here we have the fruits of true humanism, of true culture, which is ever aiming at the establishing of an inward equilibrium in the individual as in the state." These words of a renowned poet of the present age foreshadow the counsel I would offer to you for your guidance through life. While, on the one hand, the principle of the division of labor, without which human progress is inconceivable, restricts the functions of the individual within a comparatively narrow province: on the other hand, he only can wisely elect to labor in such a province, and can work the field profitably, who does not lack comprehensiveness. There is no science which has not its æsthetic side, as there is no study of form which may not be advanced by having a basis in fact. Philologists and historians of late have been desirous of having their studies classed among inductive sciences; the investigator of Nature feels more and more every day that he has, perhaps, too long neglected the deductive method. And philosophy itself, the science of sciences, can it subsist without a fundamental knowledge of the grounds of all the sciences? Without philosophy any high degree of intellectual development, in any direction whatever, is inconceivable. Even they who turn away with contempt from Philosophy are, in spite of themselves, compelled to have recourse to her. She alone brings clearness in thoughts upon the nature of one's chosen pursuit—thoughts from which there is no escape for whoever thinks!

Let it then be your firm resolve, students of the high-school *par excellence*, not to attend the lectures simply of one faculty, or of one branch of a faculty. Be true to the principles of a *universitas literarum*. Over and above the studies special to your future calling, do not fail to acquire as liberal an education as possible. Postpone purely specialist studies to the time when you will not only have to receive, but also to give—to produce. Hold in high esteem the ancients in all things wherein they were and still are our teachers. Despise not your less remote predecessors and your contemporaries the world over in matters wherein they alone are the authorities.

THE SPONTANEOUS-GENERATION CONTROVERSY.

By Rev. W. H. DALLINGER, V. P. R. M. S.

IN the present position of biological science in relation to this important and interesting question, any positive results which have a definite bearing on the difficulties of the subject, and point hopefully to new methods of research, must be warmly welcomed. Prof. Tyndall's beautiful series of experiments "On the Optical Deportment of the Atmosphere in Reference to the Phenomena of Putrefaction and Infection" are precisely of this class, and will give new impulse and direction to all unbiased labor. It is to be regretted when, in a matter so purely one of rigid science as this is, impassioned controversy is suffered to have any place. It fails utterly of its intended purpose, and simply hinders and delays the final issue. There are few but will have admired the animation, courage, and resolution, manifested by Dr. Bastian in the discussion of this question during the last five years; but those who have been most capable of understanding the method, nature, and objects of his experiments, and the general drift of his reasoning, are those who most earnestly disavow the perhaps unconscious, but nevertheless too palpable, advocacy of a *thesis* which his writings so freely display.

Dr. Bastian's position in relation to the origin of minute organic forms has, at the outset, the immense disadvantage of being adverse to the whole analogical teaching of Nature, down to the uttermost depths of minuteness, *where our knowledge is accurate and sound.* Wherever science has put down the landmarks of possession, and is not dealing with the disputable territory of hypothesis, it is absolutely known that at some period in the cycle of development the lowliest organisms are dependent for their propagation upon what we can only look upon as genetic products.

Manifestly, then, it must be weighty—nay, unequivocal and even irresistible—evidence that will induce the philosophical biologist to

conclude that Nature's otherwise universal method is changed, in the outmost fringe of organized being. Mere reasoning could never accomplish this. It must be hard, defiant fact, which none can gainsay. But verily no such facts—nor even their most distant forecasts—are before us. The profound difficulties which bristle round the inquiry on every hand are prominent signals for caution; while the uncertainty and incompetency of the methods hitherto employed, and their conflict of results, is alive with meaning. Indeed, we are dealing with organisms so minute as to elude all but our best optical appliances; and the accurate and correct interpretation of the details they enable us to discover requires the practice and experience of years. Of the developmental history of these organisms themselves, we know from actual observation almost nothing with certainty; and the little we do know from such careful and patient observers as Cohn, Billroth, Ray, Lankester, and others, is so complex and conflicting as to demonstrate the necessity of years of patient experiment and skilled research, and to plainly tell us of our ignorance of this minute and wonderful group of organic forms. And yet, forsooth, we are asked, upon the conflicting testimony of a multiplicity of boiled infusions, yielding often even in the same hands uncertain results, and in different hands conflicting ones, to believe that organic Nature—whose method of reproduction is the same to the very limits of *certain* knowledge—changes its method in this uncertain and cloudy region.

Of course, to "spontaneous generation" as a mode of vital reproduction there can be no *a priori* objection. Let us have it by all means, if it be a fact in Nature; but not on any other terms. Is it reasonable to suppose that such men as Darwin, and Huxley, and Tyndall, and Burdon-Sanderson, and Cohn, and Billroth, and Lankester, would shrink from "spontaneous generation" because of the "consequences" to which, strangely enough, it is by some supposed to lead? The very thought admits of nothing but ridicule. And yet Dr. Bastian is displeased with Darwin[1] because he has not definitely determined whether all living things originated in one primordial germ, or originated spontaneously in multitudinous centres scattered over the earth's surface. Both Huxley and Tyndall are in effect charged with grave inconsistency,[2] because, while they admit the origin of all vital forms by evolution, they yet declare that they have never *seen* an instance of "spontaneous generation" of organized forms. It is asked, "Why should men of such acknowledged eminence in matters of philosophy and science as Mr. Herbert Spencer and Prof. Huxley promulgate a notion which seems to involve an arbitrary infringement of the uniformity of Nature?" I dare not answer for them; but for myself I answer, Because the facts as presented to them on the subject—as well known to them as to Dr. Bastian, and we may venture to say as well considered—do not appear

[1] "Evolution and the Origin of Life," pp. 13–17.

[2] Ibid., pp. 15, 16.

to involve the "arbitrary infringement" of Nature's uniformity of which Dr. Bastian speaks. If these admittedly competent and proverbially fearless men could be led by facts to see that their teaching promulgated an "arbitrary infringement" of Nature's method, is it rational to suppose that they would persist in it another hour? The very position, therefore, of the leading biologists of the day in relation to the hypothesis of "spontaneous generation," is an authoritative declaration of the invalidity of the data on which it rests.

To Dr. Bastian, nevertheless, the "facts," such as they are, have carried a different conviction. But, on analysis, that conviction is evidently not wholly formed upon the bare "facts." It is influenced and stimulated by a "philosophy" which, in short, is this: Continuity in Nature is the grand outcome of all modern research; but if you are to have this in a sense wide enough to include the organic world, you must have "spontaneous generation." Give up this, and continuous evolution is impossible; *therefore* abiogenesis *must* be a great truth.

Of course, continuity in Nature is a profound truth. Every careful and comprehensive student of modern biology will admit that. By Dr. Bastian's own showing, Huxley, Darwin, and Spencer, are its most competent expositors. But they prefer not to be hasty. They decline to determine the exact manner or line of that continuity *until they have facts of a competent kind to guide them.* There may be lines of continuity infinitely more subtile than any the subtilest minds have even conceived. At least they decline to accept one, laid down, as it appears to them, not by Nature, but by Dr. Bastian; and no believer in the evolution of living things, surely, is recreant of his creed who declines a similar surrender.

The largest difficulty surrounding the question of the mode of origin of septic organisms is that of discovering their life-cycle. By dealing with them in aggregations we run told and untold risks. The conflict of results by this means, in the most accomplished hands, employing the most refined methods during the past eighteen years, is a sufficient witness. Repetitions of experiments, and conflicting results, and explanations of the reason why; and so the cycle rolls. Of course, important lessons in biology are learned, but not *the* lesson. And yet by the teachings of this complex and doubtful method *alone* Dr. Bastian is content to accept "abiogenesis" as a great fact in Nature.

To those who are best acquainted with the experimental history of the subject for the last twenty—but certainly for the last six—years this is the more remarkable. For the weight of evidence is certainly not only *not* in favor of "abiogenesis," but is in the strongest sense adverse to it. The most refined, delicate, and continuous researches all point to the existence of what are at present ultra-miscroscopic germs. This, indeed, is directly affirmed by the authors. A single

and recent instance will suffice. After a remarkable series of experiments detailed before the Royal Society, Dr. W. Roberts says: "The issue of the foregoing inquiry has been to confirm in the fullest manner the main propositions of the panspermic theory, and to establish the conclusion that *bacteria* and *torulæ*, when they do not proceed from visible parents like themselves, originate from invisible germs floating in the surrounding aërial and aqueous media." [1]

But, further, this has been remarkably sustained by analogical evidence. There are putrefactive organisms that closely approximate to the bacteria in form, structure, and size. These are the "*monads*," or, as Prof. Huxley doubtless more fitly names them, the *heteromati*.[2] They live side by side with the bacteria in the same putrescent mass, and certainly in the later stages of the disintegration of dead organic matter are the most active and powerful agents. From their greater size they present a more promising field for microscopical research than the bacteria themselves; and the life-history of some of these could be fully mastered. I long since felt that valuable aid might thus be rendered to the discovery of the nature of the bacteria. Armed with the best and most powerful appliances which the modern optician could supply, Dr. J. Drysdale and myself ventured on the work. The results are fully detailed elsewhere.[3] It need only be re-

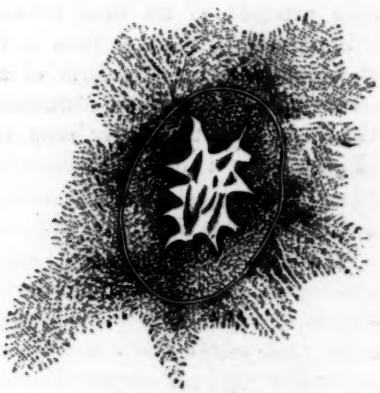


FIG. 1.

marked here that the only hope of success was in *continuous* observation of the same form, in the same drop of fluid, under the highest powers. The secret, therefore, was to find a means of keeping the same drop under examination without evaporation. This we did.[4] The result was, that patient work enabled us to completely unravel

[1] "Philosophical Transactions," 1874, p. 475.
[2] *Macmillan's Magazine*, February, 1876, p. 379.
[3] *Monthly Microscopic Journal*, vols. x.–xiii.
[4] Ibid., vol. xi., pp. 67–69.

the life-history of six of these organisms. These life-cycles cannot be here recounted. Suffice it now to say that each of them multiplied enormously by self-division (fission), but that the life-cycle in *each case* began and ended in *a distinct genetic product*—call them what we choose—spores, germs, or ova.

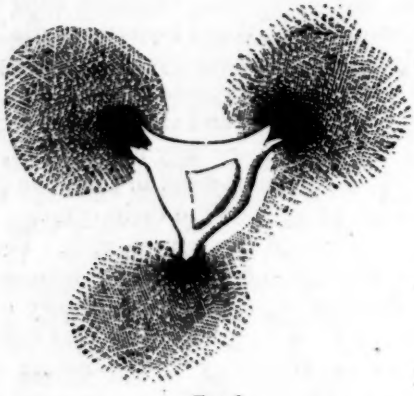


FIG. 2.

I have drawn from Nature, in the six respective cases, the condition presented by each organism at the time of emitting its spores. Fig. 1 is the genetic product of an oval monad, with a pair of *flagella;* it rapidly increased by fission; then in a remarkable manner a pair blended, became *one* in the form of a sac, the sac burst and poured out, as the drawing portrays, innumerable spores, which were watched continuously until they were seen to develop into the parent condition. Fig. 2 gives a similar product of another form, dif-

FIG. 3.

ferent anatomically and in all the details of metamorphosis, but yet passing through the states of fission, blending into a sac, and (as seen) the emission of spores; which were again watched into the parent con-

dition. Fig. 3 shows the direct genetic product of a third, but this sac did not contain spores, but *living young*, which swam forth at once upon the bursting of the sac, and by taking in pabulum at all points of the sarcode rapidly grew to the parent size. In Fig. 4 we have new features. The organism is oval, with one *flagellum*. It multiplies with enormous rapidity by *multiple* fission,[1] and then by distinct genetic union a sac is formed and spores emitted; but they are packed in a glairy fluid, and were so minute that at first our best powers

FIG. 4.

failed to reveal them. But they were afterward seen, and their full development traced. In Figs. 5 and 6 we have the same products of the last two monads. In morphological detail they greatly differed from all the preceding ones, and from each other. But the spore-sacs were produced by the same means, and the exquisitely minute spores poured forth were traced through all their stages to the adult condition.

We have here, then, important indications of fact concerning the nearest allies of the bacteria: they develop from germs.

We have, besides, the weight of the best experimental evidence pointing clearly to the existence of germs in the bacteria themselves. But the microscope has failed to *demonstrate* the latter. Its finest powers and finest methods failed to reach them.

Happily at this juncture Prof. Tyndall has stepped in, and, with his accustomed brilliance and precision, has opened up the path we need. *He has presented us, with a physical demonstration of the existence of immeasurably minute molecules of matter—utterly beyond the reach of the most powerful combination of lenses yet constructed—which are the indispensable precursors of bacteria in sterilized infusions.*[2] In short, he has opened up a new and exact method, which

[1] *Monthly Microscopical Journal*, vol. xi., pp. 69, 70.

[2] *Nature*, January 27, 1876, p. 252; and February 3, p. 268.

must lead to a scientific determination of the existence and nature of the bacteria-germs. His beautiful experiments on the decomposition of vapors, and the formation of actinic clouds by light, led him to experiment on the floating matter of the air, and with what results is widely known. Confined and undisturbed air, however heavily charged with motes, becomes at length, by their deposition, absolutely clear, so that the path of the electric beam is invisible across it. From this, and associated indications, he acutely inferred that "the power of developing life by the air, and its power of scattering light, would be found to go hand in hand;" so that a beam of light sent across the air into which infusions might be placed and examined by the eye, rendered sensitive by darkness, might be utilized with the best results in determining the existence of bacteria-germs. To bring the idea to

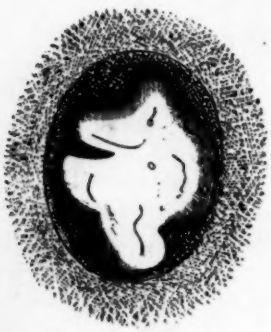


FIG. 5.

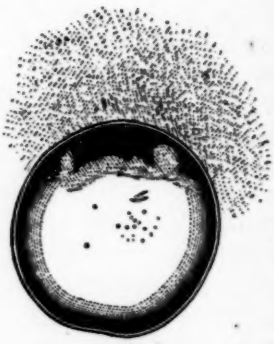


FIG. 6.

a practical result a number of chambers were constructed with glass fronts. At two opposite sides facing each other a couple of panes of glass were placed to serve as windows, through which the electric beam might pass. A small door was placed behind, and an ingenious device was arranged to enable a germ-tight pipette to have free lateral, as well as vertical, motion. Connection with the outer air was preserved by means of two narrow tubes inserted air-tight into the top of the chamber. The tubes were bent several times up and down, "so as to intercept and retain the particles carried by such feeble currents as changes of temperature might cause to set in between the outer and the inner air."

Into the bottom of the boxes were fitted large air-tight test-tubes, intended to contain the liquid to be exposed to the action of the moteless air.

"On September 10th the first case of this kind was closed. The passage of a concentrated beam across it showed the air within it to be laden with floating matter. On the 13th it was again examined. Before the beam entered, and after it quitted the case, its track was vivid in the air, but within the case it vanished. Three days quite

sufficed to cause all the floating matter to be deposited on the sides and bottom, where it was retained by a coating of glycerine, with which the interior surface of the case had been purposely varnished. The test-tubes were then filled through the pipette, boiled for five minutes in a bath of brine or oil, and abandoned to the action of the moteless air."

In this way the air in its normal condition was freely supplied to the infusions, but of mechanically suspended matter it could be demonstrated that there was none. And it was proved, with a clearness that admits of no quibble, that infusions of every kind, animal or vegetable, were absolutely free from putrefactive organisms. "In no single instance. . . . did the air which had been proved moteless by the searching beam show itself to possess the least power of producing bacterial life or the associated phenomena of putrefaction." But portions of the same infusions exposed to the common air of the Royal Institution Laboratory at a continuous temperature of from 60° to 70° Fahr., fell invariably into putrefaction; and when the tubes containing them amounted to six hundred in number not one of them escaped infection—they were all "infallibly smitten." Here is irresistible evidence that there is a direct relation between a mote-laden atmosphere and bacterial development. The whole series of Dr. Tyndall's exquisite experiments is simply an irrefragable affirmation of this truth. The presence of the physically demonstrated motes is as essential to the production, in a sterilized infusion, of septic organisms, as light is to actinic action. They cannot be made to appear without the precursive motes; they cannot be prevented from appearing if the motes be there. That these are the germs of bacteria by themselves, or associated with minute specks of matter, approximates to certainty in the proportion of hundreds of millions to one.

A beautiful illustration of the minuteness and multitude of the particles is given. Let clean gum-mastic be dissolved in alcohol, and drop it into water; the mastic is precipitated and milkiness is produced. Gradually dilute the alcoholic solution, and a point is reached where the milkiness disappears, and by reflected light the liquid is of a bright cerulean hue. "It is in point of fact the color of the sky, and is due to a similar cause—namely, the scattering of light by particles small in comparison to the size of the waves of light."

Examine this liquid with the highest microscopical power, and it appears as optically clear as distilled water. The mastic-particles are almost infinite in number, and must crowd the entire field of the microscope; but they are as absolutely ultra-microscopic as though they had no existence. I have tested this with an exquisite $\frac{1}{16}$ of Powell and Lealand's, employed with a new and delicate mode of illumination for high powers,[1] and worked up to 15,000 diameters; but not the ghostliest semblance of such particles was seen. But at

[1] *Vide Monthly Microscopical Journal*, April, 1876.

right angles to a luminous beam passing among these particles in the fluid "they discharge perfectly polarized light. . . . The optical deportment of the floating matter of the air proves it to be composed, in part, of particles of this excessively minute character," and it is among the finest of these ultra-microscopical particles that Prof. Tyndall finds the sources of bacterial life. It is almost impossible to conceive a nearer approach to certainty concerning the nature of these minute particles than this. Their minuteness, their capability of being physically demonstrated, the absolute necessity of their presence to the origination of bacteria in sterilized infusions of any and every kind, taken in connection with what we *know* concerning the germs of the *heteromita* whose life-histories have been studied, render it simply inevitable that we have at length reached, what we are justified in believing to be, a genetic product of the bacteria through which their continuation as organisms is preserved. When first I saw the simplicity and beauty of this method, it struck me that its applicability as a test in reference to germs—*known to be such*—would have considerable collateral weight; and a method of employing it was suggested by a fact in past experience.[1] I had in my possession a maceration of cod's head, which I had kept in use for eleven months. It had become a pulpy mass, and in the middle of January last it was comparatively free from bacteria, but swarmed with two monads—the fourth and sixth of the series described by my colleague and myself. To ascertain their exact condition, I watched them on the "continuous stage" for three consecutive days, and found that both forms were to be seen plentifully emitting spores. The maceration had become very short of moisture, which served my purpose. I subjected it to a drier air with a higher temperature, and it was not very long in becoming a moist pulpy mass, with sufficient cohesiveness to be removed from the vessel; and in this condition it was placed in a heating-chamber, which was slowly raised to a temperature of 150° Fahr., and kept at this for an hour. This was 10° Fahr. higher than Dr. Drysdale and myself had proved necessary to destroy absolutely every adult form. The baked mass now appeared cracked, porous, and flaky. In parts it was extremely friable, and with little pressure crumbled into almost impalpable powder; while by friction a very large proportion was reduced to the finest dust. To avoid all possibility of error this powder was again exposed in the heating-chamber, spread over a plate of glass, to a temperature of 140° Fahr. for ten minutes—thus rendering the plea of mere desiccation impossible.

A chamber or box was now prepared precisely like Prof. Tyndall's, except that there were no tubes to communicate with the outer air.

In the "Researches" on the life-history of monads we had proved that they could live, thrive, and multiply, almost as well in Cohn's "nutritive fluid" as in the normal animal infusion. This fluid is com-

[1] *Vide Monthly Microscopical Journal*, vol. xii., pp. 262, 263.

posed of phosphate of potash, sulphate of magnesia, triple basic phosphate of lime, tartrate of ammonia, and distilled water. If these ingredients are all mingled the fluid becomes speedily charged with bacteria, unless hermetically sealed, and sometimes even then. We therefore keep the ammonia in a separate solution, mixing them when required.

A portion of the fine dust of the maceration was now taken and thoroughly scattered through the air of the prepared chamber. The condensed beam from an oxyhydrogen lime-light[1] was then sent through it. Its line of passage was far more brilliantly marked inside the chamber than in the outer air. It was deemed inexpedient to insert the fluids while such brilliant points were visible in the air, and four hours were suffered to elapse. The lime-light beam was still visible with perfect distinctness, but its path within the chamber was much less brilliant and more homogeneous than it was without. The fluids were then carefully mixed, and five small glass basins of the mixture were inserted. The whole was undisturbed for five days. At the expiration of that time the beam of the lime-light sent through the chamber was absolutely invisible, although perfectly clear in the open air on both sides of it.

The fluids were now withdrawn. Ten "dips" were taken out of each basin for microscopical examination. *In every "dip"*—that is, fifty in all—*one or other of the monads appeared, and were in a state of active fission;* and in twenty-seven of the "dips" both monads were found. Bacteria swarmed the field, which of course I fully expected.

I now took five *other* glass vessels, and inserted them with great care into the now moteless air of the chamber, and poured in, as before, fresh Cohn's fluid. They were exposed for another five days. On careful microscopical examination of seventy-five "dips" *not a single monad of either form appeared;* bacteria were feebly present, but of course no steps were taken to guard against these, and, as before, they were anticipated.

The air of the chamber was again impregnated with dust, as before suffered for a time to settle, and *these same vessels of fluid*, which had yielded negative results, were again placed in the chamber. At the expiration of five days they were again examined, *and one or other of the monads was found in every successive "dip."*

Now let it be observed that there can be no possible error as to the forms. They were the identical species of the maceration, with which I am as familiar as with a barn-door fowl. What, then, is the logic of these facts? Dr. Tyndall proves that bacteria only develop in sterilized infusions when the air around them is laden with motes of incalculable multitude and exquisite minuteness. Given the pres-

[1] This was of course very much less capable of "searching" than the electric beam; but it served for the rougher end I had in view.

ence of these, and the development of bacteria is inevitable. The inference is that the motes are *germs*. The above experiments show that, in closely allied septic organisms, the germs of which have been demonstrated and their developments watched, if the dry *débris* of a maceration in which these forms are found be scattered in the air around a prepared fluid, and demonstrated by similar optical means, the said organisms develop; but if the minute dust from the *débris* be optically proved to be *absent*, none of the monad-forms appear. Here we do not hypothecate a germ, but we *know* that it exists; and its deportment in similar conditions is identical with that of the assumed bacterial germ. Do we need more irresistible evidence that the bacteria develop, not *de novo*, but from genetic products?

Evidently Dr. Bastian thinks we do. He tells us in effect that, if Dr. Tyndall has not succeeded, others have, in seeing bacteria reappear in infusions that have been exposed to a boiling-heat for five minutes. This is true; but not to the extent nor with the meaning Dr. Bastian claims. He furnishes a list in *Nature*,[1] for example, of those who are supposed to have secured the results he insists on. But this list is, perhaps hastily, but in effect, most unjustly framed. It is not surprising to see strong protests from the investigators concerned.[2] The citing of Roberts, for example, or Lankester and Pode, or Pasteur or Schwann, is simply a meaningless exercitation to all but the ignorant. Stripped of all disguise, the number of cases of the appearance of bacteria in sealed infusion after five or ten minutes' boiling is few and doubtful indeed. But still there *are* cases, and in one instance at least admirably attested; but they are confessedly exceptional in a high degree. Dr. Bastian, however, prefers to interpret Nature from the exceptional flasks, and infer "spontaneous generation" rather than be guided by the cumulative and overwhelming evidence of the existence of bacterial germs, as the medium of their normal reproduction. This must mean either that he believes that these organisms originate *de novo as well as* by germs, which is a direct *petitio principii;* or else that he is incapable of seeing the force of the facts which render the existence of germs inevitable. From the conflicting evidence of his own writing it would almost appear that he endeavored to maintain *both* these views. He has recently said, "Prof. Tyndall's results, admirable as they may be in themselves, *are altogether collateral, and do not bear upon the main point at issue.*"[3] Surely the "main point at issue" is the mode of origin of bacteria, and we cannot get much nearer the origin of an organic form than by tracing it to a genetic product—a spore! This *was* originally Dr. Bastian's question—did bacteria originate *de novo*, or from parents? It is not so now. He says, "*The* question is, not

[1] February 10, 1876.

[2] E. G., *Nature*, February 24, 1876, p. 324.

[3] *Times*, January 29, 1876.

what air does or does not contain, since I have long ago shown . . . . that boiled fluids can be made to putrefy and swarm with bacteria in closed flasks, from which air and whatever it may contain has been expelled."[1] The same reasoning also obtains in his communication to the *Lancet*[2] and to *Nature*.[3] The result is clear. The doctrine of "spontaneous generation" rests upon *exceptions* for its truth. In rare instances, and in special infusions, bacteria have appeared after prolonged boiling. After a careful sifting of the evidence, the meagreness of the testimony is striking. All that can be fairly taken at all, when justly weighed, if taken altogether, is not equal to the evidence given by Dr. Burdon-Sanderson.[4] But it is well known that, while admitting and publishing the facts, he ignores absolutely Dr. Bastian's inference. And surely this is the truer philosophy. Let it be granted that, by means not now explicable, the germs of bacteria, destructible in filtered infusions at a boiling temperature, are feebly, and at times, able to survive a slight continuation of the boiling-point in infusions containing solid particles without apparent injury—is not that a ground for inquiring the reason why, rather than for inferring "spontaneous generation?" If we can prove that in ninety-nine cases out of one hundred *actual germs* are destroyed at 212° Fahr., but that, in exceptional circumstances, the remaining one case yields bacteria *after* exposure to 212° Fahr. for some minutes, is not that a reason for inferring, and looking for, some protective influence upon the germ, rather than launching into an hypothesis of a new mode of origin?

That the medium in which minute organic forms are subjected to heat exerts an influence on their subsequent deportment I can abundantly prove. I am equally convinced that the death-point of bacteria-germs hovers very near the boiling-point of water—a conviction amply sustained by fact. This being so, the survival, as germs, of some few, amid incalculable myriads, by some accidental protection, is surely possible. So that, indeed, all true work now should be a study of the *germ* and its properties, and a discovery by patient research of the life-history of the organism.

The valueless nature of mere temperature experiments on such organisms, as tests of their ability to survive, without a knowledge of their life-history, Dr. Bastian, *without knowing it*, has made sufficiently plain. He gives a brilliant illustration—styled by himself "typical"—of the futility of his own method. Consider the facts.

In our "Researches" on the monads, my colleague and myself made it a special point to institute a series of investigations on the points of temperature which the adults, and the spores, of each form studied could resist. The results were as unexpected as they were remarkable. Only the results can here be stated. Taking the spore-

[1] *Times*, January 29, 1876.
[2] February 5, 1876.
[3] February 10, 1876.
[4] *Nature*, January 9, 1873, vols. vii. and viii.

sacs of the several forms in the order in which our illustration gives them, the data are as follow, viz.: Fig. 1 survived after exposure to 250° Fahr.; Figs. 2 and 4, 300° Fahr.; Fig. 3 (which produced living young), 180° Fahr.; Figs. 5 and 6, 250° Fahr. That is to say, the spore, *after the heating to the above-named temperatures*, were followed step by step until they reached the parent condition. The adults of each form were absolutely destroyed at from 130° to 140° Fahr. Thus, if all the examples be taken together, it will be seen that on the average the spore have a capacity to resist heat better than the adult in the proportion of eleven to six. This is surely important.

Now, until Dr. Bastian's promised "new results" [1] have appeared, I believe I am justified in affirming that the strongest cases on which even he relies for "spontaneous generation" are recorded on pp. 175–180 of his "Evolution and the Origin of Life." They are thus introduced: "After this I may, perhaps, be deemed fully justified in quoting two *very typical* experiments for the further consideration of those who stave off the belief in spontaneous generation—either by relying on insufficient reasons for doubting the influence of boiling water, or because of their following Pasteur, Cohn, and others, in supposing that certain peculiar bacteria-germs are not killed except by a brief exposure to a heat of 227° or 230° Fahr. For even if we could grant them these limits, of what avail would the concession be . . . . in the face of the following experiments?" The details of the experiments follow. They are alike in method, and we will concern ourselves only with the second. A strong infusion of common cress, with a few of the leaves and stalks of the plants, were inclosed in a flask, which was hermetically sealed while the fluid within was boiling. It was then introduced into a digester and gradually heated, and afterward kept at a temperature of 270–275° Fahr. for twenty minutes, and was retained at a temperature, if the time of heating and cooling be considered, over 230° Fahr. for one hour. This flask was opened after nine weeks. The reaction was acid; the odor was not striking. On microscopical examination with a $\frac{1}{12}$-inch objective "*there appeared more than a dozen very active monads.*"

Now, fortunately, Dr. Bastian has not only carefully measured and described these organisms, but he has drawn them, and they are reproduced on the frontispiece of the book. He describes them as the $\frac{1}{4000}$ of an inch in diameter; they were provided with a long, rapidly-moving lash (*flagellum*), by which granules were freely moved about. But, besides this, "*there were many smaller, motionless, tailless spherules, of different sizes, whose body-substances presented a similar appearance to that of the monads*—and of which they were in all probability earlier developmental forms." [2]

Now, by careful comparison, I find that this monad is no other

[1] *Vide Times*, January 29, 1876.

[2] "Evolution," p. 178.

than the "uniflagellate monad," which is the fourth in the series whose life-histories were studied by Dr. Drysdale and myself.[1] Figs. 7 and 8 will help to make this clear, where Fig. 7 is an exact rendering of Dr. Bastian's monad magnified 800 diameters; and Fig. 8 is a drawing of the "uniflagellate monad" described by my col-

FIG. 7. FIG. 8.

Fig. 7, a Monad found by Dr. Bastian in an infusion after heating up to 275° Fahr., said to be spontaneously generated.
Fig. 8, the same Monad as seen by Dallinger and Drysdale, and the spore of which (Fig. 4) survives 300° Fahr.

league and myself, magnified 2,500 diameters. We describe it thus: "Its exterior form is extremely simple, being ovoid, with a single *flagellum*. Its long diameter never exceeds the $\frac{1}{4000}$ part of an inch" in length.[2] Now, from a very prolonged and careful study of these organisms, I am convinced that Dr. Bastian's form and ours are absolutely identical. But to make the thing simply irresistible we have further and final evidence. One of the metamorphoses of this monad on its passage to multiple fission is that it loses its *flagellum*, and becomes precisely what Dr. Bastian saw all around—a motionless spherule.[3] These little bodies are less in diameter than the active monad, and of precisely the same structure. The identity is thus complete. The evidence is as full as may be; the monad Dr. Bastian saw was the one whose life-history was fully worked out. As usual, it multiplies by fission, but the fission is multiple. It then passes to a sac-like condition, resulting from the uniting together or fusion of two individuals. This sac becomes still and bursts, as seen in Fig. 4, pouring out spores that taxed our highest powers and closest watching. The spores of only two of the monads studied survived after exposure to a temperature of 300° Fahr. *This is one of them.*

Now, Dr. Bastian says, "A drop of the fluid containing several of these active monads was placed for about five minutes on a glass slip in a water-oven, maintained at a temperature of 140° Fahr. All the movements of the monads ceased from that time, and they never afterward showed any signs of life."[4] *This is precisely our experience.* But now mark the reasoning. This monad was killed at 140° Fahr., *but it was found in an infusion that had been heated up to* 275° Fahr.; THEREFORE *it must have originated de novo.*

[1] *Monthly Microscopical Journal*, vol. xi., p. 69, *et seq.* [2] P. 69, ibid.
[3] P. 69, ibid. [4] "Evolution and the Origin of Life," p. 179.

But it has been shown that the monad has germs, and that these have a power of resisting heat up to 300° Fahr.—that is to say, 25° Fahr. higher than that to which Dr. Bastian's infusion *was* exposed—and *therefore*, by the logic of facts, the monads found were not a result of "spontaneous generation," *but were the natural outcome of a genetic product contained in the infusion, and which the heat employed could not destroy.*

We need no stronger proof of the futility of reasoning concerning the thermal death-point of a minute organism where developmental history is wholly unknown. Yet so confident is our experimenter of his result that he says: "Nothing that has yet been alleged, by way of objection to the admission of spontaneous generation as an every-day fact, at all affects such experiments as these. The shortest way out of the difficulty would, therefore, be to doubt the facts." But I think I have shown a still shorter way "out of the difficulty," and that without the discourtesy of doubting Dr. Bastian's experimental "facts."

The truth, then, is that Dr. Bastian had no real knowledge of the monad; but he argued as if he had. Hence assumed premises led to a false and fatal conclusion.

He is simply repeating this in his latest attitude in reference to the question of the mode of origin of bacteria. Compelled to yield all else, he throws up a rampart round his exceptional flasks, and declares "spontaneous generation" to be impregnable—an inviolable law of Nature. Dr. Tyndall is plainly told that his knowledge is insufficient, that he has mistaken the meaning of the question, and that his mode of treating it is "laughable;"[1] and all this arises from the fact that Prof. Tyndall dealt with the question of *the mode of origin* of bacteria generally; whereas, to have pleased Dr. Bastian, he ought to have explained some exceptional conditions to which he now points —the exceptions being more important than the rule!

What are the facts?

1. Dr. Tyndall has proved, in connection with a host of others, but in a more definite and precise manner, that in *filtered infusions* five minutes' boiling does kill every form of bacteria.

2. He has further shown that they are propagated by demonstrable germs *only*, in such infusions; and—

3. This fact removes the probability of their spontaneous generation to an almost infinite distance.

As to the development of bacteria in infusions charged with solid matter, precise experiment of a sufficiently comprehensive character has yet to be made on them, in relation to the demonstrated germs. Meantime, shall we accept "spontaneous generation" on such ground as its strongest advocate has now to offer, and ignore the vast chain of facts copiously attested and controlled, which are in perfect har-

[1] *Lancet*, February 5, 1876, and *British Medical Journal*, February 5, 1876.

mony with the known laws of the entire organic world? This, and nothing less than this, is what Dr. Bastian inculcates and demands.—*Popular Science Review.*

SCIENCE IN THE ARGENTINE REPUBLIC.

By Prof. C. GILBERT WHEELER.

MUCH is being done in the Argentine Republic of South America, not only for the advancement of general education, but for the extension of science. The foreign still preponderate over the native workers, yet there is a creditable showing of contributions to science on the part of the indigenous talent of the country. With its universities and colleges, its observatory, Meteorological Bureau, Academy of Science, Argentine Scientific Society, museum, and scientific journals, with its rich and yet little-studied flora and fauna, recent and fossil, the Argentine Republic has large and promising facilities for training scientific investigators, and for vigorous progress in the elements of a higher civilization.

The republic now has, in addition to the considerable number of foreign eminent men of science domiciled within her borders, a few natives, mostly younger men, who are devoting themselves to scientific pursuits. A still larger number are becoming interested in the subject, sufficiently so, at least, to give much time to the collection of specimens, making of experiments, or the recording of observations, besides often expending in connection therewith not inconsiderable sums of money. There is Moreno, the young, bold, and successful explorer of Patagonia; Ramorino, the student of the phenomena exhibited by the famous Rocking-Stone at Tandil; and, as to the supply of careful meteorological observers, our eminent countryman, Dr. B. A. Gould, of the National Observatory and Director of the Meteorological Office, says:

"There seem to be persons enough who are able and willing to undertake the necessary labor of making systematic observations, troublesome as it is, with no other stimulus than their desire to serve science and their country. In three cases I have found gentlemen who have carried on observations of the sort during past years (up to eighteen), unaided and unencouraged. These have cordially offered me all their data, gratified at seeing their labors appreciated at last. I think this young nation, so long struggling with foreign enemies and internal dissensions, has reason to be proud of the number, relatively large, even though intrinsically small, who are ready to work for her welfare and honor, without hope of personal glory or emolument."

Buenos Ayres, "the Athens of South America," has a scientific society denominated "La Sociedad Científica Argentina," with ninety-four active members, mostly natives, although the president is a

Scotchman, the distinguished chemist, Prof. J. J. J. Kyle. Like all similar societies with us, it has had an ebb-and-flow experience, and, judging from the annual report for 1875, now before me, the monthly *séances* in that year were not prolific in scientific memoirs.

The regular monthly meeting, which should have been recently held, was transformed into an excursion to the steamboat-landing to welcome the daring explorer, Moreno, a member of the society, and who had just returned from a long and hazardous expedition, made without companions, and for scientific purposes, in the wilds of Patagonia. The society turned out in strong force, and, accompanied by many other friends and admirers of the "Livingstone of South America," as he has been called, proceeded to the pier, where a scene of enthusiastic embracing ensued, which I imagine must have been serious to one with a less firm *physique* than that of Moreno. Thereupon the noisy, good-humored throng accompanied him to his home, where a repast was served. The society has in contemplation a public dinner to the explorer, at which it is probable he will give some information as to his experiences and the scientific results he has gathered.

The rooms of the society are central, very comfortable, and well supplied with scientific periodicals. There are seven hundred books in the library.

The society offers prizes of a gold medal, suitably engraved, to be given as rewards for the satisfactory solution of scientific problems. These were for 1875:

1. The most important applications of chemistry to the industries of the country.

2. The most important applications of physics to national public works.

3. The best method of utilizing the raw materials of the country.

4. The best material for general construction suited to the republic.

5. The best method of manufacturing materials of construction.

6. The best work on physico-natural science, or its industrial applications.

7. The best work on exact science, or its applications.

The awards for the previous year were:

Luis Gardella. For a steam-engine with multiple boiler.

Conrad Forrer. For an electric clock.

M. Puiggari. Memoir on the manufacture of sulphuric from the raw materials of the country.

Julius Lacroze. Memoir upon the utilization of the hard woods of the country in the pavement of Buenos Ayres.

Vincent Gaetani. For the manufacture in the republic of artificial marble.

It appears to be the custom, on the 28th of July, to celebrate the anniversary of the society by a *conversazione*, at which ladies are also present. An exhibition of objects of scientific interest was this

year displayed on that occasion, and proved to be a very interesting feature.

The *Academy of Sciences* is formed from the scientific faculty of the National University at Córdoba, with the addition of other men of science in various parts of the country. The eminent zoölogist, Dr. Burmeister, of Buenos Ayres, is at the head of the Academy, and the members of the scientific faculty of the university are in the anomalous relation of being under the direction of the Academy rather than the university in their duties to the latter.

The secretary of the Academy is at Córdoba, his office being in the buildings of the university, where are also located the scientific collections of the Academy. These consist of:

1. The Mineralogical Museum, containing a rich and very well arranged collection of minerals, altogether the best in the country. The Argentine minerals are particularly well represented and classified according to provinces. There are microscopic preparations accompanying many of the respective minerals and rocks. The collection occupies two rooms.

2. The Botanical Collection is crowded into a room about thirty-six by twelve feet, and entirely too small to admit of appropriately arranging the numerous and interesting specimens.

3. The Zoölogical Collection, which in condition of specimens and lack of arrangement is a disgrace to the curator of this department.

4. The Physical Cabinet occupies three rooms and is a large and quite well arranged collection of apparatus.

5. The Chemical Laboratory is in two of the basement-rooms, one of which is very large. It is well equipped, but the apparatus is not kept in the best order, nor the library which appertains to this department.

6. The Library of the Academy is separated into sections, and the books distributed in the various rooms, where are located the various collections appertaining to the sciences of which they severally treat.

It is proposed soon to rearrange the collections of the Academy, put them in order so far as they are in need of it, and, where requisite, move them into more desirable and commodious apartments. They will, however, remain as now, the material for scientific illustration of the National University courses of instruction.

The glory of the Argentine Republic in the direction of work accomplished for science, and, as far as I am informed, of South America as well, is the National Museum at Buenos Ayres, of which the distinguished zoölogist, Dr. Burmeister, whose reputation is European as well as American, is the director. To a man of science this museum offers as great attractions as any of the leading ones in Europe, and there are many specimens found here, particularly in the department of paleontology, that are entirely unique. Remains of the huge animals of the sloth and armadillo families have nowhere been found so

abundantly as in the valley of the Plate; in fact, most are unknown in other parts of the world. The National Museum at Buenos Ayres has a collection especially of Glyptodons and Megatheriums unequaled by any museum in the world; has, indeed, of the former a greater number than are to be found in all other collections. These fossils, found in the Argentine Republic, are objects of special legislation, inasmuch as Congress has by law forbidden their exportation except with the consent of the director of the museum. This consent is given only in those cases where duplicates equally good and interesting are already in the museum. Dr. Burmeister informs me that there are but three specimens of the Glyptodon anything like complete in European museums, and that in the United States he believes there are none. Even those which are in Europe are imperfect in some important features; none of them, for instance, showing the interesting annular connections between the carapace and the base of the tail, thus very much marring the symmetrical appearance which the fossil in reality possesses. The Glyptodon, as will be remembered, is one of the most conspicuous objects in the collection of casts of fossils made at Rochester, and now found in several American museums.

During my stay in Buenos Ayres there has been exhumed a more perfect Glyptodon than any yet in foreign museums, and, as Prof. Burmeister has the same species, I have bought it and shall bring it to the United States.

Besides the remains of extinct animals, the National Museum is rich in specimens of recent fauna, particularly insects. It also contains many objects of archæological and historical interest. Its mineralogical collection is of very trifling importance.

At present the museum appears to be overfilled, and it is evident that larger accommodations than the present are very much needed.

Dr. Burmeister has published the *Anales del Museo Público* now for a number of years, which contains excellent and detailed descriptions of many new species, the originals of which are in the museum. In this work the huge edentates and other mammalia which have made this museum so famous are described and figured.

Scientific Journals in Buenos Ayres.—In 1873 there was published a journal devoted to science, denominated *El Ateno Argentino*. It, however, expired, after six numbers had appeared. It was, I believe, a monthly.

The following year in May the *Anales Científicos Argentinos* was begun as a scientific monthly, of about thirty-two pages each number. The copy now before me contains about twenty pages of original investigation, the balance *excerpta* and translations. Five numbers of this journal appeared when the Mitré revolution, which for the time being paralyzed so many undertakings, extinguished also this laudable private enterprise.

A few months ago the Sociedad Cientfica Argentina, of which I

have already spoken, commenced the publication of a monthly journal entitled *Anales de la Sociedad Científica Argentina*, which appears to be a creditable periodical, and I trust will live and prosper.

There is also published in Buenos Ayres a semi-scientific journal, called the *Anales de la Sociedad Rural Argentina.*

That there is some taste among the general public for scientific reading is exhibited by the circumstance that the daily papers find it worth their while to frequently admit scientific articles.

THE NATIONAL OBSERVATORY AT CÓRDOBA was established in 1872, under the Sarmiento administration, our distinguished fellow-countryman, Dr. B. A. Gould, being placed in charge as director, which position he still holds. The observatory has done splendid work for science since its establishment. A series of maps of the heavens, from the pole to several degrees north of the equator, is in course of preparation under the title "Uranometria Argentina." It is expected to contain about 85,000 stars, 35,000 of which are now for the first time corrrectly mapped. It is far advanced, and will be a monumental work when completed.

A meteorological office is also under Dr. Gould's supervision, and it is intended, when the arrangements now under way are completed, that the Argentine Republic shall also have her "Old Probabilities."

There is a school of mines in the republic, also two schools of agriculture. They, however, are too recently established to admit as yet of important results in their respective spheres.

BUENOS AYRES, *March*, 1876.

AMERICAN COLLEGES *VERSUS* AMERICAN SCIENCE.

BY F. W. CLARKE, S. B.,

PROFESSOR OF PHYSICS AND CHEMISTRY IN THE UNIVERSITY OF CINCINNATI.

AMERICA, when compared with other first-class nations, occupies a low position in science. For every research published in our country, at least fifty appear elsewhere. England, France, Germany, Austria, Russia, Italy, and Sweden, outrank us as producers of knowledge. Our original investigators in any department of learning may almost be counted on the fingers. Fifteen or twenty chemists and physicists, as many mathematicians and astronomers, and a somewhat larger number of zoölogists, entomologists, botanists, and geologists, would fill out our meagre catalogue. Among these few discoverers a comparatively small proportion are of high rank. There may be in the United States, all told, twenty men of really notable scientific standing, although there is no one to compare in actual achievements with Sir William Thomson, Helmholtz, or Regnault. In geology we

make a pretty fair showing, perhaps, because of the great facilities for research offered by our surveys and exploring expeditions. The newness of our country has also been of advantage to our zoölogists, who have not failed to improve their opportunities. But in chemistry and physics, the two sciences most intimately connected with our greater industries, we have accomplished very little.

Several causes have combined to bring about this state of affairs. There is native ability enough in America to carry on work of the highest order, but inducements and opportunities have been lacking. The labor of developing new regions, of building up commerce, manufactures, and agriculture, of constructing railroads, bridges, and telegraphs, has diverted public attention from matters apparently of a more abstract and less immediately practical character. Material necessities have taken a natural precedence of intellectual wants. Now, having laid our foundations, we begin to think seriously about the future superstructure.

But apart from all these drawbacks to American scientific growth, there is yet another of almost equal magnitude. This is to be found in the system (or rather lack of system) which has shaped our higher education. Our country is dotted over with a multitude of so-called colleges and universities, which have sprung up, not in response to any well-defined necessity, not under the developing influence of broad and clear ideas, generous culture, and wise motives, but because of personal ambition, sectarian jealousy, or petty local pride. States have conferred charters almost indiscriminately, without reason or forethought. Any body of trustees, no matter how ignorant or how foolish, has had but to ask for university powers, and the request has been granted. Incapacity on their part, or injudiciousness in their plans, has seemed to offer no impediments. This policy may be democratic, but it certainly is not wise. Its chief result must invariably be to degrade the standard of education. A college or university charter should be issued only with extreme care, and to fully responsible persons. It ought to demand compliance with certain rigid conditions, and should be forfeited whenever the institution holding it falls below the proper standards. But the mischief has been done, and science has suffered. Let us see how.

In order that science may flourish in any community, several things are needful. There must be a general appreciation of its true value to the world, a clear understanding by men of culture as to the best means for its promotion, facilities for both study and research, and suitable inducements to attract intellectual labor. No matter how able and enthusiastic an investigator may be, he can do little without apparatus or specimens, encouragement, and the means of support. Indeed, the last-named, or bread-and-butter element, is a very important feature of the problem. The human brain is a marketable commodity, at the service of the best-paying master. Payment

may come partly in the shape of fame, but something of a decidedly material nature is demanded also. A man may love science devotedly, and yet be starved into adopting some more lucrative profession.

Suppose, now, that a young man of culture, genius, and enthusiasm, wishes to devote his life to science. He has received the necessary training in his favorite branch, and simply asks for an opportunity to apply his attainments both to bodily support and to the extension of human knowledge. At the very start the chances are against him. Many such men are annually driven by necessity out of the field of science, and forced to seek a maintenance in trade, manufactures, or some other department of industry. That a great deal of valuable talent is thus wasted, and turned into channels unsuited to its development, there can be no doubt. That so much good work has been done in a society where so much is lost, speaks well for the human intellect, and shows that real ability is commoner than the majority of people suppose. If seed never fell by the wayside, but only in fruitful places, our views of human nature would soon undergo a wonderful change.

But in the case of our particular novice, employment is at last secured as "Professor of Natural Science" in an average American college. In fact, scarcely any other career would be open to him. Now, how many of the requisites for success are likely to be at his command?

To begin with, he encounters a board of trustees among whom not one has the remotest idea of what science is, or what is essential to its growth. He is called upon by these gentlemen to "teach" chemistry, physics, astronomy, botany, zoölogy, mineralogy, geology, physiology, and perhaps Paley's evidences on top of all. For study and research he has neither time, books, nor apparatus. For study, indeed, he is not supposed to need any time; and if he should press this necessity upon his employers, he would probably be told that he ought to know his lessons before attempting to teach. His students come to him miserably prepared, caring little for what he considers important, and regarding his instruction as so much of an impediment between them and their degrees. And for all this he may receive less than a thousand dollars a year, and that with a feeling of precariousness and uncertainty. At last one of three things happens: he is either called to a chair in some respectable institution, gives up teaching altogether for another less annoying occupation, or else, his enthusiasm quenched and his aspirations gone, settles down into a dreary rut, to rust out the remainder of his days.

This picture may seem exaggerated, and yet it is wholly within bounds. Many men have been ground through the mill of an unendowed country college professorship, and know how hard and thankless were the tasks assigned for them to do. In such a position the true man of science can very rarely find either appreciation, encourage-

ment, facilities, or pecuniary reward. Discouragement of the most wearing kind will, in nine cases out of ten, be his lot.

The American college system, then, is clearly an impediment in the way of American science. It acts adversely in several modes, and these I purpose tracing.

There are to-day in America over five hundred institutions claiming the name of college or university. Of these more than forty are in the single State of Ohio. Some are exclusively for male students, others receive only young ladies, the majority are arranged for the co-education of the sexes. Every religious sect, or fragment of a sect, is represented: Baptists, Free-will Baptists, Seventh-day Baptists, Presbyterians, United Presbyterians, Cumberland Presbyterians, Episcopalians, both High-Church and Low-Church, Methodists of divers complexions, Adventists, Swedenborgians, Friends, Unitarians, and Universalists: all control special institutions, equipped and endowed with due reference to the perpetuation of sound faith, and, incidentally, to the encouragement of what is supposed to be learning. Among Catholics, who now control seventy-four colleges, the intersectarian character is strongly marked, and institutions are recognized as especially Jesuit, or Franciscan, or Benedictine, or managed by the Christian Brothers, or by the Congregation of the Sacred Heart.

Now, there are several ways by which this sectarianism in education works mischief to science. The very fact that a college has been established for theological purposes, or for ecclesiastical aggrandizement, is adverse to good scientific research. Even though the teacher of science may not be directly hindered, the studies which are of especial value to theological students will be given undue prominence. In fact, nearly every American college emphasizes the classics and literary studies, and looks upon natural science as something of minor importance, often as a dangerous accessory, which must be tolerated, but not encouraged. A college catalogue which now lies open before me, after announcing that full provision has been made in its course for the inculcation of religion and morality, asserts that "scientific culture is of value only in so far as it is based on a true conception of God, and our relation to him." Such a statement as this, viewed from the standpoint of any particular sect, will usually be found to mean more than the mere words indicate.

But the great injury to science is done by the unnecessary subdivision of forces. Forty institutions spring up where only one is needed, and nearly all of them are necessarily weaklings. Libraries, cabinets, apparatus, buildings, and faculties, are foolishly duplicated. Each college lives in a continual struggle for existence, doing inferior work, and paying miserable salaries to an inadequate corps of teachers. If there were such things as Presbyterian mathematics, Baptist chemistry, Episcopalian classics, and Methodist geology, such a scattering of educational forces would be pardonable; but, as matters really

stand, it is a nuisance for which no valid excuse can be found. Here there seems to be a real conflict, not between religion and science, but between the injudiciousness of religious people and the requirements of scientific research. Where one good laboratory should exist, we have forty small and inferior sets of apparatus, each fit only for elementary instruction, and wholly unsuited to purposes of investigation. Thus the very institutions which we should naturally expect to advance science have been made by sectarian spirit incapable of yielding solid results. Other branches of learning suffer also, only science is most impeded of all. The classics, mathematics, philosophy, or literature, demand few appliances. Give the professors a fair library, perhaps some maps or charts, and a recitation or lecture room apiece, and all is provided for. But science, to be properly taught, demands much more. There must be not only laboratories and apparatus, but material and specimens; and these all cost much money. No wonder, then, that a poor institution cramps its scientific teachers, and offers meagre opportunities for the prosecution of their best and most valuable work.

Going a step beyond this curtailment of material means, we shall find that the division of forces again operates contrary to science in the selection of professors. In the first place, poverty compels a college to demand more work from a professor than any man can well do. A teacher who is called upon to instruct elementary students in half a dozen distinct branches cannot accomplish much real work in any one. Every branch of science is vigorously growing, and can be properly taught only by one who has the time to keep abreast of its growth. A large majority of American college professors are now incompetent, because the policy of college management keeps them so. Let us glance at a few of the professorships which some country colleges have established. Here, for example, is McCorkle College, situated in Eastern Ohio, whose ministerial president is "Professor of Hebrew, Natural, Mental, and Moral Science." Surely this gentleman, if his professions are honest, must be the most learned scholar in the world. His "moral science" would, of course, prevent him from undertaking any work which he was incompetent to do. We cannot suspect a "reverend" of hypocrisy in such a matter as this. In Maryland, New Windsor College contrives to neutralize scientific heterodoxy with a "Professor of Abstruse Science and Religious Instructor." Such a teacher can easily take time by the forelock, and inoculate the minds of his young charges with a proper disrespect for the awful notions of Darwin, Tyndall, Huxley, Draper, and company. Another Maryland college, St. John's, rejoices in a "Professor of Natnral Philosophy, Chemistry, Mineralogy, and Geology, and Lecturer on Zoölogy and Botany." Penn College, in Iowa, has a "Professor of Natural Science and Political Economy;" and Eminence College, Kentucky, a "Professor of Biblical Literature, Mental Philosophy,

and Chemistry." Even in New York State there is Hobart College, with its "Professor of Civil Engineering and Chemistry, and acting-Professor of Mathematics and Modern Languages." Professorships like these are by no means rare; they are the rule rather than the exception. A very large majority of our so-called "institutions of learning" employ Jacks-of-all-trades to do the work of instruction, and how well that work is likely to be done we can easily imagine; indeed, it is difficult to understand how a conscientious man can undertake such tasks. Every teacher who is competent to teach at all must know that he is unable to cover so much ground, and should refuse to be a party to such fraudulent teaching. Fraudulent is not too strong a word to use in this connection. An institution which receives money from its students in payment for an education such as it cannot give, is certainly guilty of fraud. These frauds are the natural outgrowth of improperly-granted charters, incompetent or ignorant boards of trustees, and reckless sectarian pride. Every denomination seems to be imbued with the characteristic American anxiety for display, and the establishment of a new college is a convenient piece of clap-trap to resort to. Surely the advancement of religion ought not to render necessary such sacrifices of true principle! If false pretensions are to be thus directly encouraged by the churches, what can we expect from the people at large?

The smaller colleges, however, are not the only ones to blame in this matter of professorships. They are perforce compelled to employ smatterers, because of their inability to pay the proper number of specialists. But institutions of considerable wealth often injure science in their selection of teachers by introducing false issues into the question. Every year professors are chosen, not on account of scientific ability, but for reasons of a theological or sectarian character. If two men, one a Baptist, and the other a Unitarian, were candidates for the same professorship in a Baptist university, the former, even if very much inferior to his rival, would almost certainly be elected. There may be exceptions to this general rule, but they are very rare. Even at Princeton issues of this sort are frequently raised, and the ablest candidates have been rejected on purely dogmatic grounds. Theological soundness in such an institution far outranks scientific ability. If Laplace had lived in America, no college would have tolerated him for an instant. Almost any decayed minister, seeking an asylum, would have beaten him in the race for a professorship. Not many years ago, the ablest chemist America has ever produced was a candidate for the chair of chemistry in a very prominent Eastern college. He did not believe in the Trinity, and for that reason alone failed of an election. The immorality of such a system is manifest. When success or failure is made to depend upon a mere *profession* of belief, a direct premium is put upon hypocrisy. Incompetent men are not unlikely to be unscrupulous also. Science cannot really flourish

in America until, in this respect, the colleges mend their ways. Men must be chosen professors because of their fitness to teach specified subjects, and not on account of their notions, real or professed, concerning abstract theological dogmas. Moral character ought, of course, to be considered; but mere speculative belief, never.

Another objectionable result of college scattering is the under-payment of professors. Even our best universities have shortcomings in this respect. A teacher upon small salary is naturally somewhat unsettled in his mind, is apt to be looking about for better employment, and is liable to feel a constantly diminishing interest in his work. Stability of place and freedom from pecuniary anxiety are very important to an investigator; and just these requisites few American colleges are able to supply. A large salary is not absolutely necessary to a scholar, but a certain means of comfortable subsistence is. At present, when wholly inadequate payment is offered, there is scarcely any inducement to attract a young man into the scientific life. A professorship or tutorship may be accepted for a year or two, perhaps, just as a stepping-stone to something more lucrative, but how rarely is the teacher's vocation taken up as a career! Almost every other important occupation yields surer rewards, and a fairer prospect of attaining to a competency. A young lawyer, doctor, or merchant, if careful and industrious, may reasonably look forward to possessing at some time a home of his own, with the means of sustaining and properly educating his children. The young devotee of science, however, has rarely any such possibilities before him. His labor is as arduous as, and demands even more talent than, that of the attorney or physician, but the recompense is vastly less. If, as he ought, he gives his leisure moments to the advancement of learning, he will find his salary insufficient for the maintenance of a family. In order really to live, he must constantly be doing outside work. He will thus struggle along, year after year, in constant danger of being discharged or supplanted, and, in his old age, weary and broken down, will find himself little more than a pauper. Is it strange, then, that the best intellectual talent of America is repelled from professorial positions, and attracted into other fields of labor? Can science be expected to flourish under such a system? We pay mere popular lecturers well enough; and surely the real workers, who create science, ought to be fairly recompensed also. But we can hope for little improvement until the number of colleges is reduced, and the means of those remaining suitably enlarged. Science must offer careers to men of ability, with the rewards which capacity, skill, and faithful industry, always ought to receive.

But, after tracing all the effects produced by the division of educational forces, we shall still find other points in which our college system is prejudicial to science. Glance over the curriculum laid down in almost any college catalogue, and see how the scientific in-

struction is arranged. In nearly every instance there will be found an enormous disproportion between linguistic studies and science. As a rule, over one-half of a student's time for four years is assigned to language; the remaining half being divided between mathematics, English literature, history, philosophy, and "natural science." Chemistry, for example, is generally taught through a single term (one-third or one-half, as the case may be) of the junior year. Thus a study, extremely important both practically and as a means of culture, is pursued by a student for perhaps three hours a week during one-eighth or one-twelfth of his college course. In some institutions, undoubtedly, more time is given to chemistry; but such cases are comparatively rare. A youth will enter college with at least a year's preparation in Greek, and then will follow that study for the greater part of his four years' course; but the science from whose applications he derives direct benefit every day of his life is crowded out into an obscure corner of the curriculum, and made to seem of little value. Physics is treated like chemistry; while geology, botany, zoölogy, and astronomy, are pushed even closer to the wall.

Now, what effect has this unfair distribution of studies produced upon American science? Plainly, a very bad effect. Our scientific men must be recruited mainly from among the ranks of our college graduates, and hence the latter ought to be imbued with something of the scientific spirit. That spirit is not likely to be very strongly aroused by the present policy of make-believe teaching. In fact, an enthusiasm for science is dampened rather than encouraged in the majority of American universities. The student sees men of fair training employed to teach the classics, while the work in scientific branches is done by wholly-untrained or imperfectly-trained instructors. Frequently it happens that Latin and Greek are taught by separate professors, while a single teacher is called upon to cover all science outside of mathematics. It is easy to see what effect such a state of affairs is liable to produce upon the mind of an average pupil. He becomes accustomed to regard the sciences as comparatively unimportant. He learns almost nothing of their true relations to life, and the little which he does happen to pick up is gleaned from a few superficial lectures and two or three trivial text-books. If he fails in these studies at examination, the failure counts practically nothing against him upon graduating. In short, the college deliberately carries out a policy of scientific smattering, and the student is influenced about as might be expected. He graduates in complete ignorance both of the methods and of the aims of science, having learned only a few disconnected facts concerning the great world about him.

Very many American colleges, however, now provide what claim to be "scientific courses," running for four years parallel with those in classics, and leading to bachelor of science degrees. This fact illustrates only a sham deference to the public demand for less Latin

and Greek, and amounts to very little in favor of science. A striking case in point is furnished by McCorkle College, the learned president of which we have already referred to. Let us analyze the course laid down in the catalogue. There are three terms per annum for four years, or twelve terms in all, and in the regular classical course the studies run as follows: Latin is taught during ten terms; Greek, through eight terms; mathematics, five; history, four; Hebrew, three; natural philosophy, two; chemistry, two; geology and astronomy, one each; other studies, mainly philosophical but none scientific, seven. The modern languages seem to be omitted altogether! Then, following the schedule from which this abstract was made, comes the announcement that "the scientific department will embrace all the above course except the classics." Could a more contemptible sham be invented? Would it be possible to do more in the way of belittling science? The total omission of scientific studies would be more honest and more truly in the spirit of science. And yet this institution is empowered to grant degrees, and has the same legal authority as Harvard, Yale, or Cornell. This is, to be sure, an extreme case, but it is not much worse than a host of others. As a general rule, the "scientific course" in a Western college is the classical course, *plus* a little mathematics, and with French and German substituted for Latin and Greek. Less preparation on the part of the student is required to enter it, and every applicant is given to understand that it does not rank quite equally with its older rival. In both courses the natural sciences are similarly arranged, so that the graduated bachelor of science knows really no more chemistry, physics, botany, zoölogy, geology, or astronomy, than the supposably less scientific bachelor of arts. In fact, the great majority of so-called "scientific courses" are mere makeshifts, intended to accommodate those students who are too dull, or too imperfectly prepared for taking the more thoroughly-equipped line of study in the classics. Here, again, American colleges oppose the development of the scientific spirit, and hinder seriously the growth of American science.

It would be possible to multiply indefinitely these illustrations of weakness on the part of our college system. Institution after institution might be cited in which not science only, but all culture, is at the lowest possible ebb. Just the bare facts concerning some Western and Southern colleges would, if published here, seem like incredible exaggerations or distortions of the truth. I have beside me college catalogues which are positively grotesque in their absurdities; no satire could do justice to them. One institution in particular, situated in Tennessee, has fairly reached the point at which the sublime and the ridiculous meet. In respect to science, even some of our oldest and best universities are open to criticism. Some apply theological tests in the election of professors, and in a mild way act toward modern science as some of the Spanish universities once acted

toward the discoveries of Newton. Many others make lower standards for scientific than for classical students, seemingly upon the idea that a bachelor of science is expected to know less than a bachelor of arts. Perhaps the scientific spirit is now best represented in this country by the Sheffield Scientific School at New Haven. Here the policy of the institution seems to have been entirely shaped and guided by the Faculty rather than by the trustees. The Lawrence Scientific School did stand higher before the abolition of its special laboratory, and approximated closely to the German idea; but of late its Connecticut rival has passed it in the race. As a university, taken for all in all, Harvard is probably far ahead of Yale, but in training scientific students the latter can at present claim superiority. The Columbia College School of Mines is also a good institution, but it errs in the direction of over-thoroughness. The students have so much routine and detail work to do that no time is left for originality. The instructors, too, are overworked, so that they can accomplish little in the way of research, and they are, moreover, in many cases, underpaid. This latter evil the trustees can and should remedy. It also occurs at Cornell University, and has lost to that institution the services of several valuable men. These points are mentioned now, not hypercritically, but because they serve to illustrate certain discouragements which our scientific men have to encounter.

Now, having recognized some of the weaknesses in our American mode of conducting the work of higher education, we may reasonably ask how they are to be remedied. How shall reform be brought about, and by whom?

It is quite evident that improvement must come partly from within and partly from without. The internal management of each college must modify itself for the better, and its efforts should be strengthened and encouraged by exterior influences. From the latter, however, we have most to hope. As long as our colleges are controlled by men who do not appreciate thoroughness in scientific culture, we can expect but little from within. An incompetent Faculty is not likely to become suddenly conscientious and resign, neither are average boards of trustees prone to confess their incapacity. External pressure must be brought to bear both upon trustees and upon professors before they can be made fully to realize the responsibilities resting upon them. This pressure may come, partly from public sentiment, and partly, though later, through legislation.

But how shall public sentiment be properly shaped and made available for service? How is its natural though slow growth to be fostered and directed? Mainly by the efforts, organized and individual, of scientific men. Personally, every worker in science should strive to awaken in the community about him a comprehension of the value and the purposes of his particular branch. In other words, the real investigators ought to do more toward popularizing their discov-

eries, instead of leaving the task to amateurs or charlatans. At present, unfortunately, too many able scientific men depreciate popular work and hold aloof from it. They do nothing themselves to interest the general public, and then lament the fact that the public does not become interested. Yet just here is where the beginning must be made. With a wider public interest in science will come a deeper public appreciation, and this will develop the tendencies necessary for the improvement of our colleges and schools. Until the people see and recognize the difference between true investigators and mere collectors of specimens, between original workers and text-book amateurs, little real progress can be made.

Organized effort is also needed. Just as lawyers or physicians band themselves together, so also men of science should combine for mutual self-protection against quackery. A man who had never been admitted to the bar could scarcely be chosen to a law professorship, neither could any one but a regular graduate be elected to teach in a respectable medical school. Why should not organization among chemists, geologists, or naturalists, produce in the long-run a similar state of affairs? Such an effective organization it might be difficult to bring about, and still something could be done. Even a very little improvement would be better than no improvement at all. Local scientific societies might do good in two ways: 1. By preventing, or at least opposing, bad appointments in colleges; 2. By furnishing the means for popular lectures and field-excursions. They could also, perhaps, do something toward breaking up the present vicious and absurd mode of teaching science by mere text-book recitations, and so help forward the adoption of correct methods. An attempt to teach drawing or music by lectures only, would be universally recognized as nonsensical; the same system of instruction applied to any one of the natural sciences is equally ridiculous. Nature must be studied at first hand to be properly understood.

Through legislation also something may be accomplished. This something may be very little, but a good many littles taken together aggregate much. Just as a single dollar may be the beginning of a great fortune, so one apparently trifling measure can become the starting-point of a sweeping reform. The first step to take in this direction is to prevent the issue of more charters. Inflation is as bad in education as it is in finance. No State which already contains more than one fair college or university should permit another to be established. Let the millionaires who wish to help learning give their money to institutions already in existence, or else not give at all. No benefaction is better than a mischievous benefaction. It is not long since Massachusetts lost a splendid opportunity to inaugurate the policy here recommended. The Methodist denomination of that State were discussing the foundation of a new educational institution in or

near Boston. Harvard University at once made a very liberal offer; namely, that if the Methodists chose to establish merely a theological school, and to place the same in Cambridge, it would give them rent free the use of a lot of land for their building, and would permit their students to have access to the great library, and to attend, without expense, fifty courses of lectures. This magnificent offer was foolishly declined, and the Methodists founded, only four miles away, the Boston University—a school for which there was no real demand, and which signified merely sectarian folly. If at that time the Massachusetts Legislature had refused to grant a charter, a good move would have been made. The money bequeathed by Isaac Rich might perhaps have gone to the Wesleyan University at Middletown, making that comparatively weak institution really strong. As it was, the Methodist denomination, with more zeal than discretion, divided its forces in New England, started a college within half a dozen miles of at least three others, and contributed heavily toward the perpetuation of the present vicious policy. Tufts College is another wealthy institution close to Harvard, doing little save to adorn a high hill with brick and mortar, and wholly unable to compete with its great rival. All over the country there are to be found similar examples of what is at once multiplication of means and division of forces. Galesburg, Illinois, has two colleges: one Presbyterian, the other Universalist. Nashville rejoices in four: one Methodist Episcopal, another Methodist Episcopal South, a third for colored people, and the fourth vaguely described as "non-sectarian." This senseless scattering of appliances ought never to have been permitted. The true policy is, to establish great central universities, around which as nuclei the theological schools may cluster. A plan of consolidation among existing colleges would be difficult to carry out, but to some such plan we must eventually look for reform.

Perhaps at some future time it may also become possible to regulate colleges by law, and to compel them to maintain certain standards of scholarship. If a few institutions which are now doing sham work should be summarily deprived of their charters, and so rendered unable to confer degrees, much good would result. No Legislature, however, could as yet be induced to take such a step, even supposing it to be perfectly legal. A policy of this kind must follow after the awakening of public sentiment. But the principle that every institution of learning ought to be what it pretends to be, is unquestionable. No kind of fraud is more objectionable than fraud in education.

As a matter of course, legislation upon the college problem would have to be different in different States. Neither Rhode Island nor New Hampshire need act at all upon the question; but Ohio, Indiana, and Illinois, ought to move vigorously. In these and other Western States, especially the States which sustain universities at public expense, a healthy and judicious system of taxation might be desirable.

If every college controlled by a private corporation was energetically taxed, the weaklings would soon be either suppressed entirely or forced to consolidate with other stronger institutions. Ohio alone has at least a dozen colleges which taxation would affect in this way. At present, they are public nuisances; united, they might become a source of public good.

SOCIAL EXPERIMENTS IN UTAH.

By J. H. BEADLE.

THE social anomaly of Utah is of interest not only to the politician and the philanthropist, but also to the scientific student of society, whose object is simply to find out how the thing works. Though not claiming to be a sociologist, I have had considerable opportunity to observe the operation of social forces among the Mormons, and in this article I wish to present some conclusions that I have formed relating chiefly to the economical aspect of the matter.

Judging from the tone of much of the Eastern press, one might conclude that most thinkers regarded Utah as an exception to the rules which govern other human societies; as we read frequent eulogies on its people and their progress, coupled with innocent wonder that such institutions could have produced such results. It seems to be conceded by these writers that in one part of the world a whole people may be Asiatic in religion and social type, and European in energy and intellect; at the same time going forward in wealth and culture, and backward in intellectual and moral discernment. Facts and figures may show, however, that what we should have looked for, reasoning deductively, is really there, although a little disguised at first. To treat it first in its purely economical aspects, I lay down the broad principle that, in this climate and on this soil, a polygamous community cannot get rich.

For, first, polygamy tends to the multiplication of the helpless, to make the proportion of consumers to producers unnaturally large. The political economist knows that the surplus year by year accumulated in the United States is small compared with the popular idea of it—rarely exceeding three per cent. This, funded and in turn made productive, measures the general increase of wealth. Suppose, now, some factor introduced which should consume this three per cent. of increase: it would result that the people would be pressed down upon the verge of poverty, and wealth would augment no faster than population, perhaps not so fast. Polygamy has just this effect.

True, the children are all the while growing toward the age of self-support (which in the West may be set at eighteen years); and,

could all survive, this evil would in time correct itself. But, under ordinary circumstances, forty per cent. of the race die before reaching that age. So of this increase beyond monogamic rates all is a present loss, and forty per cent. an absolute loss. But this is not the worst. The ratio of consumers to producers must in any case vastly increase before any of the young become self-supporting. Hence a much smaller surplus, a smaller ratio to each of what sustains and cheers life, and less to bestow upon the weaker, who have extra needs; consequently a stronger pressure by the whole community on the means of subsistence, a sharper struggle for existence, and a considerably greater mortality among the feeble children. This in turn increases the dead loss set forth above; and thus polygamy causes the loss beyond recovery of a part of the productive energy of a people appreciably greater than is lost in monogamy. This it is, doubtless, which causes much of that large infant-mortality in Utah, which so many have noted, and which has often been mistakenly attributed to the purely physiological effects of polygamy. It is not that children are born with weaker constitutions, but that too many of them are born for the productive strength of the community to carry.

This position will be best appreciated by a comparison with any locality in the Central West—say, a rural region in Ohio. There about one-fifth of the whole community are producers. One-half are children, one-half the remainder women (whom political economy does not consider as producers), and a small proportion infirm and aged. Given freedom, monogamy, and natural conditions, this proportion will maintain itself with almost perfect constancy. There will always be a certain proportion of unmarried women. Families will average four or five children each, and the annual increase will be such as the productive capacity of the Commonwealth can carry, and leave a slight surplus to add to its funded wealth.

Now, introduce polygamy, apportion the single women, and possibly import a few more. Give every fifth man two wives and two sets of children, every tenth man three, and every fiftieth man from four to twenty—this is about the condition in Utah—and what then? In ten years, instead of one-fifth, only one sixth or seventh of the whole population will be producers; and the number of the helpless will be greater than the aggregate strength of the community can provide a proper surplus for. Inevitably, then, the whole population will press harder on the means of subsistence, there will be less abundant nourishment, and a weakening of vitality among the poorest, and, in no long time, a marked increase of mortality among the children thus imperfectly nourished; for thus does inexorable Nature restore the balance with a stern justice untempered by mercy. That Utah polygamy causes more children to be born is unquestioned; whether it would result in a greater permanent increase of the population is very doubtful. It certainly is not true that the polygamous races increase faster than

the monogamous; as witness Germans and Turks, Russians and Persians, Britons and Hindoos.

Similarly, polygamy would add from 30,000 to 40,000 children per year to the population of Massachusetts, with no increase whatever in the number of producers. In eighteen years, at least 500,000 non-producers would be added to the Commonwealth. The first result would be, as the pressure slowly increased, that children would be withdrawn from school at an earlier age, and put to severer tasks, women would more and more be forced into the field and workshop, with still a decided increase of poverty. Despite these extra exertions against it, cases of want would greatly multiply; all the weaker constitutions would encounter extra risks, because there would be both extra exactions upon them, and less surplus to provide for their extra wants; and thus the evil temporarily avoided in one direction would come around with redoubled force in another. Where monogamy, legally enforced, possibly prevents the birth of 30,000 children annually, polygamy would in time result in more than 30,000 extra deaths; there would, meantime, be less of average food, clothing, schoolbooks, cheap excursions, and healthful amusements, less of everything that makes life possible or desirable, a decided increase in the aggregate of unhappiness, and still a dead loss in the wealth of the community. That all these results are to be witnessed in Utah is the testimony of travelers of every shade of belief, though Utah is a new country, and free from many of the difficulties which would be met with in Massachusetts.

At this point a side-issue presents itself, which it may be well to consider. My observation in Utah, and comparison with Eastern communities, convince me that there is a certain normal rate of increase, beyond which it is scarcely possible for an Anglo-Saxon community to go; or, if possible, very undesirable. I mean, of course, natural increase, immigration being left out of the account. Settle a new country with nearly equal numbers of the sexes, and the population will increase very rapidly as long as the unappropriated wealth of Nature continues; it will even double, from natural causes alone, every twenty-five years, until most of the land is occupied. Then a noticeable decline in the rate of increase will ensue; and such rate will decrease with almost constant regularity as the population increases. It will be manifest in three ways: people will marry later in life, successively larger numbers will remain unmarried, and the average number of children to each family will be less. The large number of unmarried women in Massachusetts, the considerably smaller number in Indiana, and the very small number in California, are thus seen to be legitimate results of the relative ages of those communities. Of course, new inventions, enabling each producer to get more of the necessaries of life from the same amount of labor, will have a similar effect to that of unappropriated natural wealth, and this enables some

of the oldest countries to still maintain a slight increase. But, ultimately, these growing communities must reach a condition in which a very considerable part of the population will remain unmarried.

Is it possible to change any part of this by artificial methods, such as law or preaching, to increase the number of marriages? I think not. And, if it were possible, no matter on what grounds of morality or expediency urged, I firmly believe it would result in a decrease of the average happiness, and ultimately in a social degeneracy. Those philanthropists who lament with such frequency the relative decrease in marriages may justly rest for a season from their jeremiads. It is not the extravagance of women, the selfishness of men, nor yet the ambition of parents and the dissipation of contemporaneous society, that causes the decline. A decided majority of those men who remain single till late in life, or permanently, are among the most prudent and economical, often carrying both qualities to an extreme. "Stingy old bachelor" has passed into a proverb. The single man who follows some legitimate business is filling his place in an old community as well as the married man. He adds one to the producers. From this evil, if it is an evil, there can be no artificial remedy in an old society; it is to be borne as a necessary consequence of the constitution of Nature, and alleviated only by each individual's mental cultivation. This principle may also be modestly commended to those enthusiastic patriots who calculate our probable population in the year 1900. One and all, they expect the percentage of increase to continue the same, which cannot possibly be. It was less from 1860 to 1870 than from 1850 to 1860; and will be still less from 1870 to 1880. The best places are seized upon, and population must now go back and fill up the odd corners left by those who had the first pick of Nature's wealth. The phenomenon of rapidly-growing States, like Illinois and Iowa, will never be witnessed again in this nation; for no such bodies of land are to be found anywhere west of longitude 96°.

It is fitting that I should here notice one powerful corrective to the natural tendency of polygamy in Utah—the non-Mormon population. It now numbers about 15,000, and includes at least four men to one woman. It is customary to divide the people of Utah into two classes, but it should be three: the Orthodox Saints, the "Hickory Mormons," or Liberals, and Gentiles. The second class consists mostly of the native young Mormons, born in the Church, but almost universally freethinkers; for Mormonism in a family never outlasts one generation. The Orthodox may safely be set at 60,000, still more than one-half the whole population—men and women devoted to Brigham Young and the priesthood, and ready to go into polygamy or anything else at his bidding. The "Hickory Mormons" are about half as numerous; and in the various proportions of the sexes between these three classes is the most curious feature of Utah. The Liberals

alone are in natural social conditions, men and women being about equal in numbers; while of the Orthodox there are probably five females to four males. It is of course impossible to be numerically exact; but my observations in all the towns of the Territory, and in the mining-camps (Gentile), convince me that the following exhibit is very near the exact truth:

Orthodox Saints	males	27,000,	females	33,000
"Hickory Mormons"	"	15,000,	"	15,000
Gentiles	"	12,000,	"	3,000
Total	"	54,000	"	51,000
Male excess		3,000		

The census of 1870 showed a male excess of 2,056, but the great Gentile increase since that time will make it 3,000, if not more. The above table includes all ages.

Observe how unequal are the social conditions. In a purely Mormon town there is often an evident surplus of women of a marriageable age. In a mining town, such as Alta, Bingham, or Ophir, there is a distressing scarcity. In one such town of my acquaintance with 1,000 inhabitants there are barely children enough for a small school, and not women enough to form a sewing-circle! Throughout the Territory the mining towns (Gentile) are some distance up in the mountains, while all the agricultural settlements (Mormon) are necessarily in the valleys. Seeing that human nature is what it is, whether the grand passion be regarded from the moral or merely physical standpoint, one might conclude that the mountaineers would descend upon the valley towns and repeat in more modern style the epic of unwived Rome and the Sabines. This has been prevented by the lack of social intercourse between the two classes, and still more by the vast differences in their education, and habits of life and thought. As time softens their prejudices, marriages "across the religion," as our local phrase has it, are becoming more frequent.

I have laid down certain general principles from which we might, reasoning deductively, expect certain results; my observation fully confirms those results. I do not know of a man whose condition has been improved by polygamy, while I could name a score it has reduced to poverty. I cite a few cases within my knowledge, giving no names, but assuring the reader that they are well known to all old residents of Utah:

A has five wives, children by all, and a civil position which gives him $200 per month. In a monogamous community a permanent position of that kind would enable a man of business ability to accumulate wealth. To A. with his five wives it is only what $40 per month would be to a monogamist. Despite the great advance in the value of his real estate, he is to-day on the verge of bankruptcy, and unable to properly care for his families.

B is a man of uncommonly fine business abilities, and would anywhere in the States have long since been a millionaire. He has had five wives, and reared twenty children, besides having lost some by death. Five times in his life (so he tells me) he has had a good start; now he is practically without means, the rent of his real estate being consumed in the payment of debts incurred in caring for his family. For years at a time he was never without one or more children sick, and has been literally compelled to repudiate one of his wives, who is supported by her son. Two others have died, and by the most heroic exertions he is barely able to provide for the other two and their seven children, who are still too young to assist.

C holds a very high position in the Mormon Church, and two civil offices, all with good salaries and fine opportunities. In the early days, when the Church ruled everything, the Mormon Legislature made large grants to him of pasture-lands, timber-lands, and water-privileges, to all of which he enjoyed the exclusive right for twenty years. He has had six or seven wives, and children in proportion. Of several fine pieces of property he owns most are mortgaged to their full value, and he is often cruelly embarrassed for money. With such opportunities he should now have been ready to retire with a fortune.

D is an apostle with five wives and a good family to each. Having always been more a missionary than trader, he is now actually an object of charity. It is openly charged, and not very strenuously denied, that one of his wives died of want; all the others either support themselves or are supported by their children, the old gentleman not being able to support even one family. So runs the list. Even Brigham Young, with all his opportunities, cannot be considered very wealthy. He has repeatedly sworn in his entire property at less than half a million, and in his "answer" to the suit of Ann Eliza he put it at $600,000. I should not call that great wealth, for a man with a hundred and twenty children, grandchildren, and sons-in-law, hanging on his financial skirts. The assessed wealth of Utah does not exceed $28,000,000, of which it is known that the Gentile minority owns about one-half. This would leave the 90,000 Mormons no more than $140 each, a lower average, I believe, than in any other part of the United States. The question might well be raised in Congress, whether polygamy did not bring its own punishment to the men; and, if their case alone was to be considered, we might appropriately let it alone. An old lawyer who attends to much of their business gives me his opinion that in ten years nearly all the leading Mormons will be bankrupt.

Another peculiar effect of polygamy I advance, with the suggestion that it may be due somewhat to other causes. As families increase so rapidly in size, amounting in some instances within my knowledge to fifty children of one man, there must be a vast increase

in the number of deaths; the father then must suffer an amount of domestic affliction terrible to contemplate, or undergo a progressive hardening of sensibility more to be deplored, even down to a point where the death of an offspring ceases to afflict. To use an awkward commercial phrase, can a man with fifty children, reasonably certain to follow fifteen or twenty to the grave, afford to mourn the death of each one? More than one bishop has a considerable graveyard filled with his own dead. One is said to have seventeen children buried in one row—the longest grave not over four feet. One within my knowledge has thirty-two children living and nineteen dead. Whatever might be the result under happier circumstances, I can only say this of the Mormons: No people in my ken regard death so little, especially the death of young children. They claim that this indifference is a product of their faith, "Death is but a step to a higher sphere;" but I apprehend a lively religious faith, even to the point of belief that an infant is in paradise, does not have that effect. I can understand that something of the same result might follow an excessively large family anywhere; and on this point, too, my observation in Utah convinces me that there is a certain normal size for a family, best attained and very rarely exceeded in monogamy, and that an increase beyond it is productive of misery rather than domestic happiness.

A very curious and subtile effect of polygamy is a tendency toward extreme reticence, habitual concealment of the feelings. It is often said by the Mormon preachers, and daily observation confirms it, that no people in the world keep their feelings and thoughts to themselves so well as the Mormons. Your host may be torn by internal torments, but you will sit at his table many a day ere you discover it. This might be well enough, perhaps, but with it is closely connected an habitual deceit, which, of certain kinds, is all but universal in Utah. Its genesis is partly to be sought in polygamy. A man with more than one wife necessarily lives a lie, pretending an equal affection which he cannot possibly feel; and a policy of concealment is absolutely necessary to maintain peace. Going daily or weekly from one wife to another, he must preserve a determined reticence as to all that passed with the first, or resort to deceit. The wife, too, has her reasons for concealment or prevarication; it never would do to reveal her actual feelings if she means to retain her share of his affections. Whether this, continued through all the months of ante-natal growth, has a marked effect on the offspring, is a question for another branch of science; but certainly that or something else has affected the children of Utah. Deceit is a habit which easily extends from one thing to many, and the effects of this continual falsehood in polygamy are only evil and that continually. The polygamous nations are universally more deceitful in their social relations than the monogamous.

With this is to be connected another method in which polygamy

prevents the accumulation of wealth. It tends to the dissipation of social energy. The father to more than one family cannot possibly be a father to either. No man can duplicate himself; and he who begins by having three families and three homes, ends by having none. To this must be added the constant fear, of late years in Utah, of interference by the Government; and thus has been added a new and fearful element of uncertainty to the affairs of life. One result has been to engender suspicion, and a general lack of the monogamic feeling of fixedness; and these in turn prevent large organizations for business. Whatever be the true theory, as things are now, it must be admitted that the family is the cement of the civil structure—the unit, so to speak, from which are successively built up the school-district, township, county, State, and nation—and that without the unit of organization the higher forms could not be evolved. Whatever, then, introduces an element of uncertainty into the family, weakens social cohesion and lessens the ability for organization. Accordingly, we see that no polygamous people ever established a republic or even a remote approach to one; and that in Utah every kind of organization, for business or politics, is headed and managed by the priesthood. Without them it could not have been organized at all. Social cohesion is the one indispensable element in a republic: that a people may practise self-government it is necessary that an overwhelming majority should be able to trust each other, transact business, and regulate their conduct without any government at all. Their social cohesion is certainly weaker among a polygamous people, and must in some way be supplemented; accordingly, theocracy is their natural form of government, and with it springs up a paternalism which aims to take care of the affairs of everybody.

The result of these forces working together gives us the clew to the whole history of Utah. For twenty years the priesthood was absolute spiritually and temporally; the hurch directed everything and governed everybody; every detail of private life was regulated by "counsel;" every public act of the citizen was the subject of some law. Inside the Church proper were three organized governments: the ecclesiastical, the civil, and the financial and industrial. The civil government of the Territory, under the organic act of Utah, passed by Congress, September 9, 1850, was scarcely known except as a convenience by which the Church carried out decrees previously agreed upon in the School of the Prophets. The incumbents of the various offices made elective by the congressional act were first appointed by the Church; the Mormon people then cast a unanimous vote for them under the supervision of the priesthood, every voter's ballot being put on record. Only two instances are known to have occurred of an attempt at political reform. In one of the southern districts some young Mormons nominated a candidate not on the Church ticket and elected him to the Legislature. Reaching the city he was promptly

cited before the High Council, as promptly resigned, and the Church nominee was declared elected. A few dissenters in the Thirteenth Ward of Salt Lake City combined with non-Mormons and elected Bishop Woolley to the City Council. He was cited before the School of the Prophets, and subjected to savage abuse by Brigham Young, humbly apologized for his presumption, and resigned; and the regular nominee took the seat. It was the last attempt of that nature inside the Church. That patriotic class of religionists who want an amendment declaring ours a "Christian Protestant Government" would have been delighted with the state of Utah; it was a "religious government" in the broadest sense of the words. The modified theocracy set up in New England by the Puritans was red-republican communism in comparison.

Here and there an individual grew restive under this *régime*, but took good care to say nothing openly; for of all reformers those who strive to rescue men from a mental slavery receive the bitterest opposition from those they seek to aid. If such found the condition intolerable, they quietly slipped out of the Territory and sought a community where public opinion was not so oppressively unanimous. If, as sometimes happened, one failed in the attempt, there was a "man missing—supposed to have been killed by the Indians"—as duly reported in the Church paper. As to the fate of these missing men we are mostly without legal proof, but find a number of candid statements in various sermons preached by the heads of the Church. As instance the following from Brigham Young:

"Now, you apostates, keep your tongues still, lest sudden destruction come upon you. I say, rather than apostates shall flourish here, I will unsheath my bowie-knife and conquer or die! Now, you nasty apostates, clear out, or judgment will be laid to the line and righteousness to the plummet. If you say it is all right, raise your hands." (All hands up.) "Let us call upon the Lord to assist us in this and every other good work."

Of course, if we should see this quotation in a hostile report, we should reject it at once as a fabrication; but it is in the "Journal of Discourses," with a score of similar passages, the whole book being published by the Mormon Church and indorsed on the title-page by Brigham Young and his councilors. The curious reader may find the doctrine of killing apostates explained and commended in that work, viz.: vol. i., pp. 72, 73, 82, 83; vol. ii., pp. 165, 166, *et seq.*; vol. iii., pp. 226, 234, 235, 237, 241, 246, 247, 279, and in many other passages.

The results of this peculiar system of securing unanimity were curious indeed—well worth the study of the sociologist. The society became perfectly homogeneous. All traces of mental independence vanished. The people even ceased to care for it apparently. A rigid paternalism governed every detail of the social organism under the guise of what was called "counsel by the priesthood." There was

counsel to sell and counsel to buy, to go abroad or remain at home, to build a house, open a farm, buy a cow, or take another wife. The remnants of individualism which the people had brought with them from their native lands seem to have completely died out as early as 1855. Natural selection of course operated powerfully in aid of this tendency, coupled with the isolated condition of the country. From one to three thousand fresh converts arrived every year; those who could not submit at once and completely, slipped out of the Territory as soon as possible, and the residuary mass settled into a condition of unchanging homogeneity. That class of thinkers who maintain that government should take care of the people's business, finances, and morals, by prohibitory enactments as to foreign goods and native whiskey, would have been amazed to see how thoroughly Utah had carried out this policy. All the business of the people was regulated by the rulers; paper-money was issued by the city under the direction of the Church; nobody could sell liquor without the consent of Brigham, and the distance from markets created a protective tariff 200 per cent. heavier than a Congress of Greeleys and Careys would have dared to impose. Stranger still, the system was, as to the objects aimed at, a perfect success: a whole community voluntarily abdicated each man his personal sovereignty, and were taken care of by their priestly advisers with a cruel kindness which the ordinary American need not hope to comprehend. Even the desire for independence died out. An original thought came to be regarded as a sin to be repented of, confessed, and put away. Each successive and abortive attempt at something better resulted in making the population still more submissive. Where vigorous preaching had been necessary in 1850, a move of the hand was sufficient in 1860; where argument was still employed in 1860, a hint was enough in 1868. Toward the close of this period, and before the disturbing Gentile invasion, business took me on a lengthy tour through the remote settlements, where the results of over-government showed themselves most completely in the perversion or stupefaction of the mental faculties. I heard men maintain with vehemence that Jesus Christ was a practical polygamist; that the Gentile world was to be utterly desolated before 1890, and the remnant submit to the Mormon priesthood; that a republican government was a rebellion against God, in that men sought to govern themselves without counsel of an inspired priesthood and a prophet divinely appointed; and that a man could not obtain honorable rank in heaven unless he had children on earth. I heard women protest that they would not live as the one wife of a man if possible to go into polygamy; that there was no exaltation in heaven to an unmarried woman; that it was a deadly sin to refuse to enter polygamy; and that a woman or man who voluntarily remained unmarried would be a servant to the Saints to all eternity. Both sexes accepted as a religious verity that slavery and polygamy were established by

direct command of God; that the Government was at war with the Almighty in the abolition of one and disapproval of the other; and that the mass of the people of the United States were scoundrels who deserved death, and would soon be visited with all the plagues of the Apocalypse. And these people did not seem to be aware that they were insane. They argued earnestly and swore fluently in defense of their religion, quoted the Bible voluminously in favor of slavery and concubinage, and declaimed about the Prince of Peace, the way of salvation, and control of passion, till they were black in the face with anger. At the autumn conference that year Brigham pronounced the fiat—"No trade with outsiders;" and at a wave of his hand all the commercial relations of 75,000 people were changed in a day; a dozen mercantile firms had their business destroyed, and were driven from the country. Some of them could not even dispose of their stock on hand, and were forced into bankruptcy. That autumn I visited one settlement, near Salt Lake City, where a cane-mill was run night and day on custom-work. A year afterward I passed that way again; the cane-mill was resting in idleness, and the people hauling their cane miles away to another settlement. The owner of the mill had apostatized; the word from the Tabernacle had gone forth, "Drop him!" and for the first, and I hope the last, time in my life I got sight of that unique theological phenomenon—an apostate cane-mill.

Whether the moral condition was then tolerably good or very bad cannot be determined satisfactorily. There was such a dead calm upon the surface of society, and such a singular reticence among all classes, that only the most atrocious cases ever came to light—often those were not known or suspected until some of the parties had apostatized. No account was ever given in the Mormon papers of any crimes committed in the remote settlements, and so complete was the surveillance of the secret police that a case of seduction was almost immediately discovered and settled by having the parties married at once, a previous marriage of the man being no hinderance. Of two strangers visiting the Territory, one would say: "These are the most orderly, law-abiding, and happy people on earth;" the other: "There is neither liberty nor law—neither honest, earnest thought nor vigorous happiness; there is a centralized despotism, and Brigham Young is king." Possibly some idea of the moral tone may be gained by noting the prominent characters chosen for the offices, and presumably representing the priesthood and people. John D. Lee, as well known then as now as the wholesale murderer of Mountain Meadows, only a few months after that awful crime came to represent Iron County in the Legislature, received the encomiums due a faithful public servant, and went home with a young wife, "sealed" to him by Brigham Young. His colleague in murder, Isaac C. Haight, was also his colleague in the Legislature, and was in like manner rewarded with a young wife. Both these men continued high in office in the

Mormon Church until the United States marshals chased them into the mountains. Robert T. Burton, who murdered four of the "Morrisites" after their surrender, was rewarded with the offices of collector, sheriff, and bishop, and two extra wives given him. Bill Hickman, who confesses to twenty murders, was a member of the Legislature, and had during his career ten wives. Samuel Smith, Bishop of Boxelder, rejoices, presumably, in the ownership of six wives, of whom two are his brother's daughters. It is not conclusive that these men represented the average moral tone, as they were appointed by Brigham before being elected by the voters; nevertheless, I do not remember having heard the appointment spoken of with disapprobation by the people. I visited both Haight and Lee at their homes in Southern Utah, and, while the latter was under some popular condemnation, the former was a leading citizen of Toquerville. Polygamy, like slavery, is necessarily the practice of a minority—a select aristocracy; but in both cases it is to be noted that the great majority who could not enjoy its benefits, if any, were its most ardent defenders. Could this social and political condition have continued three generations, then would the future scientist have found in Utah an entirely new variety of our species—Saxons without a constitutional government, Britons with no consciousness of a personal sovereignty, Americans lacking even the wish for a republic; wives willing to share a husband's heart, maidens looking for an "exaltation" in polygamy, and children with blood relationship so mixed that no "heraldry Harvey" could ever have succeeded in tracing the circulation. From a scientific standpoint, it is almost a pity the Gentile could not have left Utah untouched for a century—it would have been such an interesting experiment. With the Gentile invasion and establishment of United States authority, the experiment practically comes to an end; but, let it be dealt with as wisely and mercifully as it may, the break-up must be attended with fearful suffering.

SKETCH OF PROF. J. S. NEWBERRY, M. D., LL. D.

JOHN STRONG NEWBERRY, whose portrait we give in the present number of the MONTHLY, was born December 22, 1822, at Windsor, Connecticut. He is sprung from old Puritan stock, his ancestors having formed part of a colony which, in 1635, emigrated from Dorchester in the colony of Massachusetts Bay, and made the first settlement in Connecticut, at Windsor. Many members of the Newberry family earned high distinction by their services in the field and in the council during the colonial period, in the War of Independence, and in the later history of Connecticut.

The grandfather of J. S. Newberry, General Roger Newberry, an officer in the army during the Revolutionary War, was for many years a member of the Governor's Council; he was also one of the directors of the Connecticut Land Company, proprietors of a great part of the "Western Reserve," in Northern Ohio. His son Henry, father of the subject of this notice, in 1824, with his family, emigrated from Windsor to the Western Reserve, and founded the town of Cuyahoga Falls, in Summit County.

Young Newberry received his academic education at the Western Reserve College, from which institution he graduated in 1846. Two years later he received the degree of Doctor of Medicine from the Cleveland Medical College. The years 1849–'50 he spent in study and in foreign travel, and in 1851 he began the practice of medicine at Cleveland. But the life of a practising physician was distasteful to Dr. Newberry, as affording but little opportunity for scientific study, for which he had from boyhood evinced great aptitude. Hence, in May, 1855, he accepted an appointment as assistant surgeon and geologist to Lieutenant Williamson's expedition for the exploration of the country lying between San Francisco and the Columbia River. The results of this expedition are published in the Pacific Railroad "Reports;" but Dr. Newberry's report on "The Geology, Botany, and Zoölogy of Northern California and Oregon" also appears in a separate quarto volume of 300 pages, with 48 plates.

He next, in 1857–'58, was attached to an expedition under the command of Lieutenant J. C. Ives, commissioned to explore and navigate the Colorado River, so as to open a route of communication with the army in Utah. An iron steamer, constructed in Philadelphia, was taken in sections to the Gulf of California, where it was put together and launched. The expedition navigated the river for the distance of 500 miles. Above the point reached by the steamer the course of the river, for hundreds of miles, is through deep cañons with vertical walls, in some places over a mile in height. The report on the Colorado region, drawn up conjointly by Lieutenant Ives and Dr. Newberry, gives a graphic description of perhaps the most remarkable portion of the earth's surface. In the preface to the report, Lieutenant Ives speaks of Newberry's observations as constituting "the most interesting material gathered by the expedition."

The following year (1859) Dr. Newberry was ordered to join a party sent out by the War Department, to report to Captain Macomb, for the exploration of the San Juan and Upper Colorado Rivers. The party traversed a large part of Southern Colorado, Utah, Northern Arizona, and New Mexico, adding greatly to the sum of geographical knowledge, and opening a region of singular interest and of enormous mineral wealth. This expedition determined the point of junction of the Grand and Green Rivers, forming the Colorado; further, it explored the valley of the San Juan, a river whose banks

for hundreds of miles are lined with the ruined stone houses and towns of an extinct race. Dr. Newberry's report of this expedition was published recently.

Upon the outbreak of the war, Dr. Newberry was elected a member of the Sanitary Commission, and in September, 1861, he was chosen secretary of its Western department. He had supervision of the affairs of the Commission in the Mississippi Valley, with headquarters at first in Cleveland, then in Louisville. In this position he displayed executive abilities of a high order. Branches of the Commission were, through his efforts, established in the chief cities of the West, and measures taken for the permanent and effective care of the sick and wounded.

In 1866 he was appointed Professor of Geology in the School of Mines of Columbia College, New York, which position he still holds. In 1869 he received from Governor Hayes the appointment as State Geologist of Ohio, and was commissioned to make a geological survey of that State. The work was carried on by Dr. Newberry and his assistants with extraordinary vigor, and was completed at the close of the year 1874.

The report of this survey is now in process of publication. Two "Reports of Progress," and four volumes of the "Final Report," illustrated with a large number of finely-executed maps and plates, have already appeared. Four volumes more, and a geological map of the State, still remain to be published. This work, though executed with unexampled rapidity, has not been carelessly done. The record already made is proof of its thoroughness, and shows that it will compare favorably with any similar survey made in this country or elsewhere; indeed, it is in the highest degree creditable to the State of Ohio, and to the geologist in charge.

Prof. Newberry's eminence as a scientific man is unquestioned. As a geologist and paleontologist he ranks among the foremost of the time. His contributions to the literature of these branches of science have been numerous and valuable, being chiefly in the departments of general geology, fossil plants, and fossil fishes. He is a member of most of our American scientific associations, and of many similar European bodies; he was one of the original corporators of the National Academy of Sciences, has been President of the American Association for the Advancement of Science, and is at the present time President of the New York Academy of Sciences (formerly Lyceum of Natural History).

CORRESPONDENCE.

EARLY TRANSCONTINENTAL EXPLORATIONS.

To the Editor of the Popular Science Monthly.

SIR: Judge Daly's address to the American Geographical Society, in the May number of THE POPULAR SCIENCE MONTHLY, it appears to me, might lead the reader to infer that little was known, before General Fremont's journey, of our country between the Mississippi and Pacific. And a like opinion seems to have been entertained when he was a candidate for President, for it was then said that he was the discoverer of the South Pass of the Rocky Mountains; whereas it had been long known and used by explorers before 1832, ten years before his journey, when I passed that way to Oregon, some account of which can be seen in a letter from me to Prof. Amos Eaton, of Troy, published in *Silliman's Journal* in 1833 or 1834, and a communication from myself to the same in 1835. But, as this may look a little egotistical, I will speak of those who traversed those regions earlier, but by no means to detract from the deserved honor due to those later explorers named by the judge in his address, one of whom, Lieutenant Gunnison, I knew well, as this place was for a time his home, as it is still of his family; and as they were the first to explore the wide country from the Mississippi to the Pacific, Lewis and Clark, and their companions, should be the first mentioned, for, till their exploration, it was indeed a *terra incognita*. Sent out by the Government in 1806, after its purchase as a part of Louisiana, it took them more than two years to perform the journey, crossing the mountains by very difficult routes, the more feasible ones, the South Pass and others, being of after-discovery. Well do I recollect in my childhood hearing one of their number, a Mr. Ordway, describe their journey, and how the *bad* Indians followed them for a number of days to restore some articles they had accidentally left. Lewis and Clark's journey was before the day of what is called the modern sciences, for to them, geologically, the grand basaltic columns on the Columbia were "*high black rocks.*" Then, in 1810, came Mr. Astor's grand enterprise of establishing the fur-business on the Columbia. He not only sent a vessel round by sea with men and supplies, but sent a party, headed by Mr. Ramsay Crooks, across the country to meet them. He met so many obstacles, especially among the mountains and cañons along the lower Lewis River, that he did not reach Astoria till the second year. The next year, to bring an express from there to Mr. Astor, a Mr. Robert Stewart, late of Detroit, crossed the mountains and plains with only half a dozen men. But Astor was cut short in his business in Oregon, for in 1812 a party of the British Northwestern Company crossed the mountains and descended the Columbia, carrying the news to Astoria of the war, and that a war-ship was on the way to take their fort. So Astor's agents there sold out to them his interest, and those British traders, afterward consolidated with and known as the Hudson Bay Company, even after the boundary-line was settled beyond the mountains, controlled the fur-trade from the Pacific to the Atlantic in British America, and down the coast to California, and knew every corner of it to the Arctic Ocean, wherever the beaver clipped a twig or swam its mountain-streams. General Ashley, and other American fur-traders, early also carried the trade to the mountains, and became as well acquainted with them on our side, if we except that wondrous cañon-region lately so ably explored by Powell and others. Mr. Sublelle, with whom and his trappers we in 1832 traveled, had then made his seventh annual journey to the mountains, and we left the State of Missouri on the deep-worn Santa Fé trail, over which trade was carried on to that place; leaving which, and crossing the Kansas River, between that and the Platte we overtook Major Bonneville, traveling with wagons to the mountains, where he passed the winter, and of whom,

as well as of Astoria, Mr. Irving gives an interesting account. We parted with the trappers on what I now know to be the Humboldt River of Utah, and in six weeks reached the Hudson Bay Company's fort, Walla Walla, through a country so poor in furs that it had been little frequented by their traders. So the Indians showed us their usual native kindness and hospitality. And here let me say, after a long acquaintance with them, that Indians, uncontaminated by the whites, are *honest*, *truthful*, and *hospitable*.

JOHN BALL.

GRAND RAPIDS, MICHIGAN, *May* 5, 1876.

THE DISCOVERY OF A SPECIES OF BORING MOTH IN FLORIDA.

To the Editor of The Popular Science Monthly.

THE notice in the June number of THE POPULAR SCIENCE MONTHLY (p. 250) of the species of *Ophideres*, moths which possess a trunk so rigid as to be able to pierce the rinds of oranges and suck their juice, has brought to light the occurrence of a species of the genus in Florida. The specimen which I have examined was taken by Mr. Roland Thaxter, of Newtonville, Massachusetts, near Appalachicola, Florida, on March 24th of this year. Mr. Thaxter, who is already known for his collections of our Northern *Noctuæ*, preparing them beautifully for the cabinet, has added greatly to our knowledge of this group; the species *Eutolype Rolandi* and *Dicopis Thaxterianus* have been named for him. The present discovery, which he has made during a winter's trip to Florida, is equally interesting. The Florida specimen seems to me undoubtedly to be *Ophideres materna* (Linn.), a species proper to the East Indies, but which Guenée records also from Brazil, conjecturing that it had been transported thither by commerce. I have examined the terebrant trunk under the microscope, and it agrees in the main with the representation of that of *Ophideres fullonica* given in THE POPULAR SCIENCE MONTHLY (p. 251). It is not possible to compare it more nearly without mounting the end of the trunk as a microscopic object, which the rarity of the single specimen prevents. It is not unlikely, now that the species is found, that it will be discovered in larger numbers, while the interesting question as to its introduction into Florida will engage attention. The most probable conjecture will associate it with its food-plant.

A. R. GROTE.

EDITOR'S TABLE.

THE PROMOTION OF SCIENCE.

THE importance of science is everywhere conceded. As affording a knowledge of the operations of Nature, which can be taken advantage of by multiplying the resources and increasing the productiveness of industry, and by guiding art into the most economical ways, everybody admits that science is doing a beneficent work for the world. And even in the region of ideas, as a basis for the formation of opinions and a corrective of old errors, the importance of science is freely acknowledged. That science is something of universal moment, and of the deepest interest it is almost superfluous to argue; its recognition is so far assured.

But science is also, and as a consequence of its importance, something to be *promoted*. It is something of which myriads of human beings scattered over the globe know nothing; which the world got along without for more ages than we can count; which slowly arose in these latter centuries and grew against steady resistance, and which has at last among certain nations come to be a separate interest cherished by a portion of the cultivated classes, and so distinctly recognized as needing care and encouragement that many organizations have arisen to promote these objects. Royal societies for the "promotion of natural knowledge," academies of science in all the chief cities, special socie-

ties devoted to each of the great branches of science, local institutions, naturalists' clubs, and large popular associations for the advancement of science, as in Germany, France, England, and this country, which hold their meetings in the different cities so as to act upon large numbers of people—all these are illustrations of the tendency to organize for the promotion of science by increasing observations, experiments, and original researches for the improvement and extension of this kind of knowledge. Nor are there many obstacles to these modes of work, save those which spring from its inherent difficulties. It is a very expensive kind of study, involving costly instruments, elaborate investigations, and extensive collections—the sending of expeditions into remote and unknown regions, and of ships around the world to scrape the bottom of the sea. The universally confessed importance of such inquiries has already secured large appropriations for these objects, and it may be expected that in future private enterprise and governmental aid will become still more available for these objects.

But there is another agency for the promotion of science, which we hold to be of far greater importance than all these immediate means and instrumentalities, and which the world has hardly yet begun seriously to consider. We refer to the alliance between science and general education. Science has hitherto accomplished its work with but very imperfect assistance from this source. Education in all its grades has been in the interest of other classes, and it does not even yet distinctly, or fairly, recognize as a class the students of Nature. There have been innumerable institutions strongly endowed, and ably equipped for the intellectual training of lawyers, clergymen, physicians, linguists, metaphysicians, historians, and literary men, but the facilities for the systematic training of scientific students have been scanty, defective, or altogether wanting. Education was highly organized before science arose, and the old institutions not only did not encourage the experimental study of Nature, but resisted it, with the whole weight of their influence, for centuries. The universities were creatures of the church and the state, and devoted to ideas, and ideals of culture, which were unfavorable for the study of natural things, and obstructive to scientific investigation. The old educational institutions have been, of course, greatly modified and liberalized in recent times, yet tradition continues in the ascendant, so that, although science has forced its way into many of them, it is still regarded with jealousy and treated as an intruder. Though within the pale of official recognition, it is dealt with as something outside of the venerated curriculum of liberal study. It has not been assimilated so as to become an integral and necessary part of our modern culture, and college authorities are still perplexed to decide how much to concede to it, and what to do with it. Scientific men have, therefore, grown up under unfavorable conditions, and have not had those advantages of early preparation, of cordial encouragement, and of long and faithful discipline, which the students in other departments have freely enjoyed. It is under these grave disadvantages that science has, thus far, advanced. Education has been made only very partially tributary to its progress. When it takes its rightful place in our schemes of study, when it is honored as other acquirements are honored, and when the higher institutions offer the same facilities for prolonged and thorough scientific discipline that they offer for training in classics and mathematics, a step will have been taken toward the general promotion of science, more important in its consequences than any measures that have been hitherto adopted.

And yet this will be but a partial step in the right direction. The bring-

ing of education into the full service of science means much more than its liberal acceptance by the higher schools. Science is a vast and a permanent interest in human society, and in considering the means of its advancement we are bound to take account of those deeper agencies which require time for the accomplishment of their results. More important for the general promotion of science than any change of policy on the part of the colleges, will be its recognition and adoption as a part of the established work of primary and common schools. The most urgent question now, and fullest of import for the future, is the relation which science is to take to elementary education. Thus far, the course of science has been a continuous battle, and it has only got what it has conquered. Its claims have been pressed by its advocates, and they have been resisted by the partisans of other studies, and we observe that the instincts of the combatants are bringing them rapidly to the vital issues of the strife. As we have often said, the most critical and important question between the old education and the new is, which shall have authority to form the first impressions in childhood. The practical inquiry is, How early shall children be allowed to begin the study of science in schools? We can imagine a future time, and we trust it is not far distant, when such an inquiry will be regarded as absurd. Science being an understanding of natural things, and a child being born into the order of Nature, with a capacity for intelligence which is awakened and unfolded only by its intercourse with natural things, what can be more preposterous than to raise the question when a child shall begin to have its attention thoughtfully directed to the objects around it? In this dawning action of the mind upon sensible things are found the rudiments of all science. Obviously, the true requirement is, that these germinal acquisitions concerning the kinds, and properties, and changes, and relations of things around, shall become matters of early attention, encouragement, and cultivation, on the part of parents and teachers; and, if this were intelligently and skillfully given, the query could never arise, When shall the study of science begin? But we are far enough from that condition now. In accordance with the prevailing ideas of education, the child is got into the schoolroom as early as possible, and, being started in a course of acquisition in which science is left out, the question at length arises, If it is to be introduced at all, when shall it commence? The advocates of the old education would never ask for it. They would occupy childhood, and youth, and manhood, with language, grammar, and book-acquisitions, so that the pupil and the student would get no more knowledge of the laws and phenomena of Nature than they had before this knowledge was discovered. And, when pressed by the advocates of the new education to make room for scientific studies, they defer it as long as they can, and allow it as little time as possible.

A very interesting controversy has gone on for some time past, in the columns of *Nature*, as to how early science is to be entered upon in the preparatory schools. All the writers profess to represent the liberal side, yet some of them who admit the importance of science assign it a low value as a means of education, and think that children should not touch a scientific subject in school until they are well grounded in Latin and geometry. This is substantially a surrender of the whole ground; yet it is the position taken in the great mass of schools in which the sciences are regarded as only fit for finishing studies. The physicists and chemists are more in earnest, and believe in the educational usefulness and importance of their subjects, but they seem more concerned about the consideration given to their chosen sciences than about the

mental needs of children, and the adaptation of objective studies to their early cultivation. They would therefore begin with physics and chemistry when boys and girls are old enough to commence simple experimenting; that is, at perhaps the age of twelve or thirteen. Mr. Wyles, of Allesley Park College, claims to have had the best success with chemical and physical experiments and the use of the microscope, and he embodies his views and results in the following instructive passage:

"I believe that such knowledge as I have indicated may be profitably given even to very young boys. They learn thereby to distinguish the precise features and qualities of natural objects, and the conditions of ordinary phenomena; and such teaching undoubtedly exercises in the best way the observing powers, which develop much earlier than the reflective faculty. I am inclined to say that teaching elementary science to boys from ten to thirteen is a greater success than teaching grammar; i. e., that the principles involved are more easily seen, excite more interest, and become therefore a better mental discipline. We rarely have boys come to us with any knowledge of science, and, when they have, it has generally been acquired from lectures, and is worthless as a means of education. We do not lecture, but do real hard class-work, and take periodical examinations on this work, giving it equal value in these and our grade examinations with language and mathematics. We have no reason to believe that this work interferes with or deteriorates the work in language and mathematics, in which subjects we find our boys quite equal, and, except in very rare cases, I may say, superior to incomers of like power, and who have had no science-teaching.

"The great number of men eminent for their vast scientific attainments, who have achieved this eminence in spite of our non-scientific, I may almost say anti-scientific system of education, clearly indicates that many of us have an inherent scientific power or genius surpassing our power in any other direction. I plead for such that they have the same chance of being floated on their scientific voyage as the linguist and the mathematician have on theirs: and I have seen no satisfactory plea why they should not. Value for value, I claim for the science-man a higher status in our present social life than is due to either linguist or mathematician.

"My experience as a schoolmaster has revealed to me many cases where the talent for language or mathematics has been so low that the education effected by these has been of the meanest kind; or where the incessant failure has produced a stolid ignorance, a kind of mental paralysis, most disheartening to all concerned. Such cases have come into my hands, and I have seen intelligence rekindled, and mental power aroused, by simple science-teaching, and the power even for other subjects enhanced thereby."

But there are others who insist that scientific studies may and should begin much earlier, and their view must be adopted before society can ever reach the solid and lasting advantages which are to be gained by scientific education. It is the teachers of natural history that favor this view, maintaining that the collection, observation, and comparison of plants, insects, shells, etc., may be made highly instructive at a period when chemical and physical experiments may not be undertaken. The Rev. George Henslow takes this decided position, and, in replying to Mr. Wilson, of Rugby, in *Nature*, of April 20th, he has the following remarks:

"Before twelve, I agree with Mr. Wilson, that practical chemistry should not begin. But, Mr. Wilson says, 'Science should be introduced into a school, beginning at the top and going downward gradually to a point which will be indicated by experience.' Surely this is inverting a fundamental principle of education, and we may ask, Why should science be thus singled out? Why not begin at the top with Latin and arithmetic and work downward? Science, however, has its 'elements' and its 'advanced' stages, like everything else. The soundest method seems to me to select the science for each age or capacity of pupils, and for the teacher himself to adapt the branch selected to them. Let him begin with botany—with children of the age of six, if he pleases—and by using the schedule he will find it almost self-adapting to the child's powers. Physical geography might come next, with pupils from eight to twelve; then the experimental sciences or geology from twelve upward. The observing of the

habits of animals might go along with any other science as an out-door instructive amusement, and be limited to no age.

"Mr. Wilson talks of the difficulty of a 'bored and weary schoolmaster teaching science informally.' Passing by the fact that, if he be bored and weary, it is largely due to his own want of interest in teaching, or in engaging that of his pupils, I would maintain just the opposite opinion—that, assuming a teacher to be such, informal teaching in natural history has a wonderfully invigorating effect, and reawakens the attention which may have become dull by monotony. Thus I have often found, during a lesson in Latin, e. g., Virgil's 'Georgics,' passages to be constantly occurring when 'collateral science' can be invoked. And, what is a proof of its value is, that it becomes suggestive to the pupils themselves, so that I have been obliged to check the superabundance of questions lest a Latin lesson should resolve itself into one on natural history.

"Beyond such informal teaching as this I would never encourage it as a principle for teachers solely to act upon with young children, though, of course, there need be no restrictions in giving it them. But if science is to be *taught* at all—and all such informal methods are not really teaching—let it be thorough as far as it goes, lest it should lapse into a slipshod informality. It is the charm of the schedule-system of botany that it demands close and accurate observation in the dissections, and the writing compels accuracy in the result, as well as impresses the facts firmly upon the memory."

CRIMINAL JUSTICE IN 1876.

ONE of the objects of this Government, avowed by its founders in the preamble to the Constitution, is *to establish justice.* The implication here is that there are such things as human rights which require to be protected, and that it is the office of government to enforce this protection. The first utterance to the world of the American people, in detaching themselves from the parent-country and proclaiming independence, was an affirmation of "inalienable rights," to secure which "governments are instituted among men." We may infer from this that it is the first, the supreme, and the acknowledged duty of the governing power in society to guarantee the rights of citizens, and to see to the strict enforcement of justice. The presumption is that, in the free interactions of citizens in the social state, wrongs will occur, rights will be violated, and injustice be done. The innocent will be circumvented by the crafty, the weak will be oppressed by the strong, the unscrupulous will combine to plunder the helpless, and, to prevent all this, Legislatures enact laws, courts are established, judges, sheriffs, and constables appointed to carry them out and secure the requirements of justice. This is the boasted theory of our civil institutions, but, after a hundred years of experience and improvement and progress, it is painful to note the enormous gap that still exists between theory and practice. That government should fail to secure its great ends in a perfect manner is what might be expected from the imperfection of all human institutions. Though devoted assiduously to this great object, such are its difficulties, and such the ingenuity of the practised perpetrators of wrong, that we should be entitled to expect from government only a very partial accomplishment of its purpose. Another and a very powerful cause of the inefficient execution of justice in society is, that government perpetually forgets its supreme function, in the pursuit of other ends. It attempts to do so many things that it does nothing well, and sacrifices the very object for which it was instituted, in the attempt to accomplish others which it had no business to undertake. Instead of confining itself vigorously to establishing justice in all the relations of society, and then allowing the widest liberty of individual action and enterprise, it meddles with everything and everybody, interfering, checking, and restraining, where it should let things alone, and undertaking to play the part of Providence in controlling the whole course of human interests. Justice is thus not only neglected, but injustice is wrought in all directions,

so that government at last becomes the instrument and partner of the great agencies of oppression and wrong-doing in society. Nor is this the worst: instead of concentrating its attention upon the transcendent duty of working out the great ends of justice, and laboring to improve and perfect the methods and appliances for attaining this object, it stands convicted as the open and shameless perpetrator of wrong, violator of the most sacred rights of citizens and the defiant executor of palpable and rank injustice. The prosecutor of criminals, it becomes itself the criminal, and cuts off its victim from all possibility of redress.

An illustration of this has just occurred, which is worth pondering over in this year consecrated to political vainglory. The newspapers inform us that "in November, 1874, Charles and Mary Fisher were sentenced in the county of New York, the former to seven and the latter to five years' imprisonment in Sing Sing, for being accessory to an outrage upon a girl. The governor has pardoned both, upon the representation of the prosecuting officer that they were innocent of the crime." Government has here perpetrated a gross injustice upon two innocent persons—deprived them of their liberty, extorted labor from them, and robbed them of the results of it, subjected them to a cruel degradation, and, when convicted of its own blundering, it lets its victims go without lifting a finger toward repairing the wrongs it has inflicted; Charles and Mary Fisher are without redress. If their rights had been similarly violated by other individuals, government would have recognized their claims to large compensation. But when its own court and its own officers are the self-convicted offenders, those who have suffered may ask reparation in vain. If a citizen is wrongfully deprived of his property by government, he may prosecute and recover it to the uttermost farthing; but, if wrongfully imprisoned, stripped of his wages and disgraced by the very authority that was constituted to mete out equal justice to all, its victims are helpless. If an American citizen were unjustly imprisoned abroad, the government would have redress from the offending nation, though at the cost of war. But when the same thing occurs under its own jurisdiction and by its own fault, all reparation is denied. It may be said that such things cannot occur often; then they are the more easily rectified, and the excuse for withholding justice is only an aggravation. But it is probable that they occur far more often than the public is aware of. For what have we to hope, in the strict administration of justice, from an authority that can itself outrage justice in so glaring a way? What are we to expect from an authority that refuses to hold itself accountable for the wrongs it does. If it be said that the government must assume the infallibility of its ministration of justice, then why liberate Charles and Mary Fisher? And, if the machinery of justice can work so ill as utterly to defeat itself, the proof of which we have in this flagrant case, what confidence have we in the proportions and measures of penalties that are meted out to real criminals? With such obtuseness and indifference to right and wrong as are evinced in this scandalous case, there is surely little confidence to be reposed in the general equities of criminal adjudication. There can be little doubt that the coarsest and most barbarous part of our administration of law relates to the treatment of the criminal classes.

PROF. HUXLEY'S LECTURES.

PROF. HUXLEY has decided that, from the nature of his engagements, he must give up all expectation of visiting the United States during the winter, and that therefore it would be impossible for him to devote a season to lecturing here. But he is coming over in August to spend a brief vaca-

tion of a few weeks in this country, and, although strongly desirous of forgetting all lecturing, and being left quietly to himself while here, he has, nevertheless, consented to give three lectures during the last week of his stay. He will speak in New York on the 18th, 20th, and 22d of September, the subject being "The Direct Evidence of Evolution." This will give an opportunity, for those persons throughout the country who are anxious to hear Prof. Huxley, to connect this pleasure with their September visit to the Centennial Exhibition. It is to be remembered that these are the only lectures that Prof. Huxley will give in this country, and they will probably be fortunate who obtain the tickets. Detailed arrangements are not yet made, but parties wishing to secure seats can do so by applying to the editor of THE POPULAR SCIENCE MONTHLY, who will register applications in the order in which they are received, the first applicants for tickets having the first choice of places.

LITERARY NOTICES.

PREHISTORIC MAN: Researches into the Origin of Civilization in the Old and the New World. By DANIEL WILSON, LL. D., F. R. S. E. Third edition, revised and enlarged, with Illustrations. In Two Volumes. London: Macmillan & Co., 1876. Price, $12.

THE first edition of this important work was issued in 1862, at a period when the public mind was startled by the rapid progress made in archæological discovery, and by the evidence it afforded of the great antiquity of man upon the globe. Vast collections of implements and ornaments had been made by the museums of Northern Europe, and by private collectors, from caves, mounds, lake-borders, and drift-gravels, but their value as a record of the prehistoric races was a subject of animated discussion. It was not admitted, excepting by those familiar with the subject, that any of the implements which had been brought to light "implied a longer period for man than that assigned by the Mosaic record."

It was vigorously denied that flint weapons found in the ancient drift-gravels were works of art. M. Boucher de Perthes published, in 1847, an account of many found in the drift-gravels in Northern France, and for many years "was looked upon as an enthusiast, almost as a madman." At such a period the appearance of Dr. Wilson's elaborate work, and of others like it, did excellent service, in presenting the facts and history of archæological science, and the conclusions it suggests.

In common with those who had made the science a subject of unprejudiced study, he asserted the great antiquity of man. "The pre-Celtic architects of the British long barrows, and the allophyliæ of the European stone age," he said, "are but men of yesterday, in comparison with the Flint Folk of the Drift. . . . They were a race of hunters and fishers . . . . contemporary with the Siberian mammoth and extinct elephants—the woolly rhinoceros—the musk-ox, and reindeer of France."

The present volumes contain an account of the principal discoveries made since the first edition appeared, and treat in interesting detail of the condition of primitive man on this continent—the aspects of culture among the mound-builders, and the miners of the Northern lakes. The civilizations of Mexico and Peru, and the shadowy ones which preceded them, are vividly presented.

Here, as everywhere else with primitive man, the author finds proof that "art is a child of necessity." Probably men learned to sharpen stones for their clubs, converting them into spears when the club was found inadequate to the necessities of their condition.

Man's earliest arts were therefore of the most practical kind, not in any sense ornamental. Indeed, ornamentation arose, in the opinion of the author, merely by improving the accidents of manufacture.

The era of the Flint Folk, he observes, may antedate the historic epoch by hundreds of thousands of years, as some archæologists insist; "still man is found to have been the same reasoning, tentative, and inventive mechanician that he now is." Nor does the author find any evidence of the anthropoid link between man and the brute. It is obvious, however, that much depends on what constitutes evidence of

that link, and scientists differ on that point.

Only that portion of the early prehistoric period is known to us of which the caves and the drift have furnished records; these, however, suggest an antecedent period, in which man may not have attained the weapon-making stage. His primeval habitat and true birthplace, observes the author, may have been in the more favored regions of the earth where Nature spontaneously provided for his requirements.

That a work so voluminous as this should pass to a third edition is strong evidence of its merit, and of the deep interest felt in the subject of which it treats. The value of the work is enhanced by the number of its illustrations, there being 132 in the 800 pages of the volumes. It is the matured and intelligent expression of one of the early students of archæology, and will continue to command the attention of the specialist and of the general reader.

THE WAGES QUESTION: A TREATISE ON WAGES AND THE WAGES-CLASS. By FRANCIS A. WALKER, M. A., Ph. D. New York: Henry Holt & Co. Pp. 428. Price, $3.50.

THE question of wages is strictly economical in its nature, and must be discussed by the political economist without reference to ethical or social considerations. Most writers on the subject of wages have, however, given to the term "economical" too restricted a meaning, thus excluding the action of causes which, though primarily ethical or social, are nevertheless secondarily potent in the field of industry, as affecting either the production or the distribution of wealth. To such causes Prof. Walker assigns due weight, and herein consists one of the distinctive features of his work. "Sympathy for labor" is a phrase which, on first view, would seem to have no place in a scientific discussion of the wages question from the political economist's point of view. Yet, as is shown by the author, if sympathy for labor serves in any degree to make competition on the side of the laboring class more active and persistent; if it takes anything from the activity and persistency with which the employing class use the means in their power to beat down wages, or lengthen the hours of work, it becomes, in just so far as it has such an effect, a strictly economical cause.

Three doctrines, which are more or less current in political economy, the author vehemently controverts, viz.: 1. That there is a wage-fund irrespective of the numbers and industrial quality of the laboring population, constituting the sole source from which wages can at any time by drawn. Wages, he shows, are paid out of current production, and not out of capital, as the wage-fund theory assumes. 2. That competition is so far perfect that the laborer, as producer, always realizes the highest wages which the employer can afford to pay; or else, as consumer, is recompensed in the lower price of commodities for any injury he may chance to suffer as producer. 3. That, in the organization of modern industrial society, the laborer and the capitalist are together sufficient unto production, the actual employer of labor being regarded as the capitalist, or else as the mere stipendiary agent and creature of the capitalist, receiving a remuneration which can properly be treated like the wages of ordinary labor.

In opposition to the generally-accepted view that, if the wage-laborer does not seek his interest, his interest will seek him, Prof. Walker holds that, *if the wage-laborer does not pursue his interest, he loses his interest.* "In a state of imperfect competition," says the author—

> "First, wages may be reduced without any enhancement of profits, the difference being, not gain to the employer, but loss to mankind through the industrial degradation of the laborer." This point is established by the case of Spitalfields, where a large population was ruined morally and socially by a great change in the conditions of the silk manufacture. "Secondly," continues our author, "for so much of the sums taken from the laboring class by reduction of wages as the employers or capitalists may at the time secure in excessive profits or excessive interest, there exists no adequate security, under the operation of strictly economical forces, that it will be fully returned to the wages-class in a quickened demand for their labor, inasmuch as luxuriousness and indolence will inevitably enter, among the majority of employers, to waste in self-indulgence a portion of the profits so acquired, or to take something from the activity and the carefulness with which future production will be pursued. Thirdly, in respect to such industrial injuries as have just been described, economical forces by themselves tend to perpetuate and continually to deepen the injury, putting the laborer at a constantly-increasing disadvantage in the exchange of his services."

The doctrine of *laissez faire* is simply a rule of conduct applicable in certain conditions, not a principle of universal application. Prof. Walker favors state interference to the extent of—1, insisting on the thorough primary education of the whole population; 2, advocating a strict system of sanitary administration; 3, insisting on the necessity of precautions for the integrity of banks of savings for the encouragement of the instincts of frugality, sobriety, and industry. "If the state," says he, "will see to it that the whole body of the people can read and write and cipher; that the common air and common water—which no individual vigilance can protect, yet on which depend, in a degree which few even of intelligent persons comprehend, the public health and the laboring power of a populations—are kept pure; and that the first feeble efforts of the poor at bettering their condition are guarded against official frauds and speculative risks, it may take its hands off at a hundred other points, and trust its citizens, in the main, to do and care for themselves. . . . It must ever be borne in mind, in such discussions, that those things are economically justified which can reasonably be shown to contribute, on the whole, and in the long-run, to a larger production, or, production remaining the same, to a more equitable distribution of wealth."

ANNUAL RECORD OF SCIENCE AND INDUSTRY FOR 1875. By SPENCER F. BAIRD. Pp. 946. New York: Harper & Brothers.

THIS fifth volume of Prof. Baird's "Annual Record of Science and Industry" is not only the most voluminous, but also the most complete of the series. The first part of the work, comprising a brief narration of scientific and industrial progress during the year 1875, is specially valuable. Each principal branch of science and industrial art is here considered separately, and the reader is enabled readily to note the amount of progress made in each during the past year, and to observe the directions in which the thoughts of practical and scientific men are tending. Such annual summaries will, in future times, be of invaluable service to the historian. This portion of the work occupies nearly 300 pages. The second part consists of paragraphs communicating in brief the results of special scientific investigations. These paragraphs are distributed under the heads of "Mathematics and Astronomy," "Terrestrial Physics and Meteorology," "General Physics, Chemistry, and Metallurgy," "Mineralogy and Geology," "Geography," "General Natural History and Zoölogy," "Botany and Horticulture," "Agriculture and Rural Economy," "Pisciculture and Fisheries," "Domestic and Household Economy," "Mechanics and Engineering," "Technology," "Materia Medica," "Therapeutics and Hygiene," "Miscellaneous." The work is provided with a good index.

MANUAL OF THE APIARY, pp. 59. Also, INJURIOUS INSECTS OF MICHIGAN, pp. 48. By Prof. A. J. COOK, of the Michigan State Agricultural College.

IN the first of these two pamphlets Prof. Cook aims to supply a want which has long been felt, that of a hand-book on bee-culture, which shall be at once simple in style, full in its discussions, low-priced, and up with the times. In all these respects he has undoubtedly attained a very fair measure of success. The injurious insects treated of in the second pamphlet are, the potato-beetle, May-beetle, pea-weevil, squash-bug, sundry enemies of the cabbage-plant, plum-curculio, grape-phylloxera, clothes-moth, etc.

STANDARD FACTS AND FIGURES. Compiled by A. G. SULLIVAN. New York: Morton & Dumont. Pp. 109.

THIS little manual contains a large amount of commercial and financial information of special importance to business-men, and to those who desire to purchase Government, State, railway, and mining stocks. The volume also contains tables of interest, exchange, prices of gold, etc. The value of the work is much enhanced by a very complete index.

PROCEEDINGS OF THE POUGHKEEPSIE SOCIETY OF NATURAL SCIENCE. Vol. I., fascicule I. Pp 41.

THIS installment of the proceedings of the Poughkeepsie Society of Natural Science consists of only one paper, by Charles B. Warring, entitled "Studies upon the

Inclination of the Earth's Axis." The author considers the following questions: How could a belt of nebulous matter acted on by the laws of motion and gravitation become a spheroid? How did the axis of the spheroid, normally perpendicular, become inclined? What was the amount of this inclination up to the moment of the earth's existence separate from the moon? When did the increase to the present obliquity occur? Finally, what was the cause of that increase?

MAN: PALÆOLITHIC, NEOLITHIC, AND SEVERAL OTHER RACES, NOT INCONSISTENT WITH SCRIPTURE. By NEMO. Dublin: Hodges, Foster & Co. Pp. 137.

THE first appearance of man upon the earth took place, according to this author, in the Pliocene, or perhaps earlier. Before the Adam of the book of Genesis there were several creations of man, and of these creations ten races besides that of *Adam* survive to this day. Thus, instead of being the *first*, the scriptural Adam was the *last* created man. After the "six days" of creation the seventh day commenced, and of that day nearly 6,000 years have run. Judging from analogy, many thousands of years have yet to elapse before the "seventh day" is ended.

ON SUPPOSED CHANGES IN THE NEBULA M 17 = h. 2008 = G. C. 4403. By E. S. HOLDEN.

THIS paper, reprinted from the *American Journal of Science and Art*, goes over the same ground as the article by the same author, "The Horseshoe Nebula in Sagittarius," in Vol. VIII. of this MONTHLY. In the latter paper Prof. Holden addresses a popular audience, and he accordingly eschews mathematics; but in the former he addresses astronomers, and of course writes in technical language.

THE PUBLIC-SCHOOL QUESTION: TWO LECTURES. Boston: Free Religious Association.

THE school question is here presented from two opposite points of view: that of "an American Catholic citizen," by BISHOP MCQUAID, of Rochester, N. Y.; and that of "a liberal American citizen," by FRANCIS E. ABBOTT, editor of the *Index*.

WHEELER'S SURVEY OF THE TERRITORIES. Reports of G. K. GILBERT, pp. 270; EDWIN E. HOWELL, pp. 70; and A. R. MARVINE, pp. 35. Washington, 1876.

THESE reports have been printed by the authors for private circulation. They are all extracted from vol. iii. of Wheeler's United States Engineer Reports of Explorations and Surveys west of the One Hundredth Meridian. The authors, in this private edition of their reports, correct various typographical errors, and restore some passages which, though occurring in the original manuscripts, do not appear in the documents as officially published. In some instances statements made in the reports are corrected in accordance with the results of more recent investigation.

MEMOIRS OF THE PEABODY ACADEMY OF SCIENCE, No. 4. Salem: Published by the Academy. Pp. 94, with Plates.

IN this elegant quarto volume the Peabody Academy presents to the public the late Prof. Jeffries Wyman's memoir upon the fresh-water shell-mounds of the St. John's River, Florida. Prof. Wyman made his first examination of these shell-mounds in 1860, when collections were made at Lake Harney, Black Hammock, and Enterprise. In 1867 he revisited these places, and soon afterward published a short account of them, of which the present memoir is in some respects a reprint. But later he had opportunities for further exploration, the results of which are here given. The collections made by Prof. Wyman are preserved in the Peabody Museum of American Archæology and Ethnology at Harvard College.

BULLETIN OF THE UNITED STATES GEOLOGICAL AND GEOGRAPHICAL SURVEY OF THE TERRITORIES. Vol. II., No. 1, pp. 87; No. 2, pp. 100.

THE first of these two numbers of the *Bulletin* of Hayden's Survey is specially interesting. It contains seven papers, nearly all of them illustrated, on archæological subjects connected with Colorado, Arizona, Utah, and other Western Territories. In number two are two essays, viz., "Studies of the American Falconidæ," and "Ornithology of Guadeloupe Island." Both of these papers are by Mr. Robert Ridgeway.

CONTRIBUTIONS TO THE NATURAL HISTORY OF KERGUELEN ISLAND. By J. H. KIDDER, M. D. II., pp. 122. Washington: Government Printing-Office.

IN this bulletin are embodied the results of an examination of the eggs brought from Kerguelen Island by the United States Transit-of-Venus Expedition, the identification of the botanical specimens, and determinations of the small but interesting zoölogical collections. The latter contain a large number of new genera and species, especially in mollusks, insects, crustaceans, and echinoderms.

OCCURRENCE OF EOZÖON CANADENSE AT CÔTE ST.-PIERRE. By J. W. DAWSON, LL. D. Pp. 10, with Plate.

THE controversy as to the true nature of *Eozöon Canadense*—whether it is of organic origin, or whether it is simply and purely a mineral formation—still continues. A short time ago we made mention of a paper by Otto Hahn, on the negative side of this question. In the paper before us Dr. Dawson presents with considerable force the arguments in favor of the organic origin of this curious fossil.

BULLETIN OF THE UNITED STATES NATIONAL MUSEUM, No. 5, pp. 82. Washington: Government Printing-Office.

IN 1872, while on a visit to the Bermudas, Dr. G. Brown Goode, assistant curator of the United States Museum, studied the fishes of those islands. The present number of the *Bulletin* contains the results of Dr. Goode's studies. His "Catalogue of the Fishes of the Bermudas" names and describes seventy-five species of fishes belonging to Bermudan waters—most of them observed by the author himself. Up to the time of his visit, only seven species of fishes had been recorded from that locality.

TRANSACTIONS OF THE KANSAS ACADEMY OF SCIENCE. Vol. IV. Pp. 63. Topeka: Printed by G. W. Martin.

CONTAINS twelve papers bearing the following titles: "Ozone in Kansas Atmosphere," "The Nebraska Hot Bluff," "Kansas Chalk," "Kansas Soils," "Kansas Salt," "Calamites," "Kansas Mammalia," "Habits of Certain Larvæ," "The Cottonwood-leaf Beetle," "Rocky Mountain Locust," "Sage Sphinx," "Lepidoptera of Eastern Kansas."

THE HISTORICAL JESUS OF NAZARETH. By M. SCHLESINGER, Ph. D. Pp. 98. New York: Somerby.

DR. SCHLESINGER, in the first place, analyzes the Messianic idea as it existed in the minds of the prophets and in the traditions of the people of Israel. He then examines the New Testament writings, in order to show what manner of man Jesus really was, and what religious and moral doctrines he held. These, according to the author, were purely Jewish—"Jesus was nothing but a Jew." The Christian system really originated with the apostle Paul, who boldly cut the new religion loose from its parent trunk, Judaism.

BULLETIN OF THE BUSSY INSTITUTION. Part V., pp. 97, with Plates. Cambridge: John Wilson & Son.

OF the seven papers contained in this volume three are on chemical subjects, viz., "The Composition of Date-stones," "Analysis of Potassic Fertilizers," "Occurrence of Ammonia in Anthracite." The author of these papers is Prof. F. H. Storer, dean of the institution. The other four papers are on botanical subjects, viz.: "A Disease of Olive and Orange Trees," "The American Grape-vine Mildew," "Fungi found in the Vicinity of Boston," and "The Black Knot." These papers are by Prof. W. G. Farlow.

JANSEN, MCCLURG & Co. announce the publication of a "Manual of the Vertebrates of the Northern United States," by David S. Jordan. The work is designed to reduce the labor of classifying and ascertaining the names of specimens, and to fill in the study of zoölogy the place that Gray's "Manual of Botany" has long filled in the study of plants. 1 vol., 12mo, pp. 342. Price $2.

UNDER the title "Condensed Classics," Henry Holt & Co. will soon commence the publication, in condensed form, of a series of standard works of English fiction, the purpose being to save the time of the reader by eliminating those portions of the text that can be spared without impairing the continuity of the story. The work of condensation is in the competent hands of Mr. Rossiter Johnson. The initial work of the series will be "Ivanhoe," by Sir Walter

Scott. This will be speedily followed by "Our Mutual Friend," by Charles Dickens, which will be succeeded by "The Last Days of Pompeii," by Bulwer.

In the prospectus of the *Quarterly Bulletin of the Nuttall Ornithological Club*, it is stated that "papers received from resident and corresponding members of the club, together with such matter pertaining to birds as may be gathered from other sources, will make up the contents. It is proposed to issue 16 pages quarterly. Starting, however, with 28, we hope to receive sufficient aid to warrant the continuation of a like number, and to make the work at least self-supporting." $1 per year. Published by H. B. Bailey, 13 Exchange Place, Boston.

The *American Catholic Quarterly Review* takes the place of the defunct *Quarterly Review* edited by the late Dr. Orestes A. Brownson. The new periodical, however, will occupy a wider field than its predecessor, embracing within its scope not only theological, philosophical, and political, but also historical, scientific, and literary discussions. It has a strong editorial staff, and among its contributors are the foremost Catholic *littérateurs* and scholars of the United States and England. $5 per year. Philadelphia: Hardy & Mahony, 505 Chestnut Street.

PUBLICATIONS RECEIVED.

The Logic of Chance. By John Venn, M. A. Pp. 488. New York: Macmillan. Price, $3.75.

Village Communities. By Sir Henry S. Maine. Pp. 425. New York: Holt & Co. Price, $3.50.

The Andes and the Amazon. By James Orton, A. M. Pp. 645. New York: Harpers. Price, $3.00.

Comparative Zoölogy. By James Orton, A. M. Pp. 396. New York: Harpers. Price, $3.00.

Elements of Physical Manipulation. By E. C. Pickering. Part II. Pp. 326. New York: Hurd & Houghton. Price, $4.00.

Ninth Annual Report of the Peabody Museum of American Archæology. Pp. 54.

Recent Advances in Physical Science. By P. G. Tait, M. A. Pp. 349. New York: Macmillan. Price, $2.50.

The Fatigue of Metals. By L. Spangenburg. Pp. 90. New York: Van Nostrand. Price, 50 cents.

Eighth Annual Report on the Insects of Missouri. By C. V. Riley. Pp. 186. Jefferson City: Regan & Carter print.

Seventh Annual Report of the Massachusetts Board of Health. Pp. 574. Boston: Wright & Potter, print.

Annual Report of the Louisiana Board of Health. Pp. 261. New Orleans *Republican* print.

Annual Report of the St. Louis School Board. Pp. 407. St. Louis *Globe-Democrat* print.

Report on the Ventilation of the United States Hall of Representatives. By Robert Briggs, C. E. Pp. 45. Philadelphia: H. B. Ashmead print.

Tenth Annual Report of the Trustees of the Connecticut Hospital for the Insane. Pp. 56. Middletown, Connecticut: Pelton & King print.

Centennial Newspaper Exhibition. Compiled by G. P. Rowell & Co. New York. Pp. 295.

Papers read before the II H Scientific Society of the Rensselaer Institute. Troy, New York. Pp. 44.

Normal Standard of Woman for Propagation. By N. Allen, M. D. Pp. 39. New York: W. Wood & Co.

The Wire-Ligature. By W. A. Byrd, M. D. Pp. 20. New York: Appletons.

Biblia Sacra Nova. Pp. 30. New York News Company. Price, 25 cents.

Catalogue of Isaac Lea's Published Works. Pp. 22. Philadelphia: Collins print.

Further Notes on "Inclusions" in Gems. By J. Lea, LL. D. Pp. 12. Philadelphia: Collins print.

Lateral Pressure of Rocks. By W. H. Niles. Pp. 15. Boston: Kingman print.

Notes on the North American Ganoids. By B. G. Wilder. Pp. 44. Salem Press. Price, 50 cents.

Distribution of the Geneva Award. By Hon. Elijah Ward. Pp. 10. Washington, 1876.

Terre Haute Public Schools. Pp. 92. Terre Haute, Ind.: *Globe* Printing-Office.

Report on Dermatology. By L. P. Yandell, Jr., M. D. Pp. 7. Indianapolis *Journal* print.

The *Missouri Dental Journal*. Monthly. Pp. 16.

The Glacial Epoch and the Distribution of Insects in North America. Pp. 5. Are Potato-Bugs poisonous? Pp. 3. By A. R. Grote. From Proceedings of American Association for the Advancement of Science.

Nothing. By W. H. Boughton. Pp. 8. Brooklyn: E. S. Dodge print.

Chemistry of Three Dimensions. By F. W. Clarke. Pp. 9. From Proceedings of American Association for the Advancement of Science.

Experimental Proof of the Law of Inverse Squares for Sound. By W. W. Jacques. Pp. 8.

MISCELLANY.

The Academy of Natural Sciences of Philadelphia.—The Academy of Natural Sciences of Philadelphia having, at the beginning of the present year, taken possession of its commodious new building, Prof. E. D. Cope avails himself of the occasion to suggest in the *Penn Monthly* some needed changes and improvements in its organization. The objects of the Academy, as stated by its founder, are, the promotion of original investigation, the imparting of instruction, and the diffusion of knowledge. The Academy possesses a moderate fund for promoting the last-named object, and publishes its "Transactions" regularly. But the other two objects do not receive the same attention. Original research is not materially encouraged by the Academy, and in one instance funds, supposed to be devoted to research, were hoarded and afterward turned over to the building-fund. Less than five hundred dollars per annum is devoted to "instruction." The chief fault found by Prof. Cope in the organization of the Academy is that, while it secures good financial management, it minimizes the scientific features of the body. "Its officers are the usual president, vice-president, secretary, etc., constituting a management as appropriate to an historical society, library company, or, I might add, church vestry, as to an academy of natural sciences. It has no position designed for its distinctive and essential feature, its scientific experts."

Prof. Cope's remedy is simply to adopt the organization which is possessed by all similar institutions the world over. "Let it create as many positions as there is reasonable probability of receiving endowments in future years, and attach to them privileges which will render them desirable to incumbents, and duties such as are necessary to the Academy."

Wyville Thomson on Oceanic Circulation.—Prof. Wyville Thomson, in a report to the hydrographer to the British Admiralty, discusses the problem of oceanic circulation, and gives reasons for believing that the bottom water of the two great oceans is an extremely slow indraught from the Southern Sea. This indraught he refers to the simplest and most obvious of all causes, viz., the excess of evaporation over precipitation in the northern portion of the land hemisphere, and the excess of precipitation over evaporation in the middle and southern part of the water hemisphere. In concluding the report, Prof. Thomson further says, "I need scarcely add that I have never seen, whether in the Atlantic, the Southern Sea, or the Pacific, the slightest ground for supposing that such a thing exists as a general vertical circulation of the water of the ocean depending upon differences of specific gravity."

The Discovery of Anæsthesia.—Dr. H. P. Stearns, of Hartford, at the close of an able "Critique on the History of Modern Anæsthesia," which appears in the *Medical Record*, sums up in the following terms the results obtained by sundry prominent claimants of the honors of discovery: 1. In December, 1844, Wells made the suggestion and applied the test in his own person, by inhaling a large dose of nitrous oxide, and having a tooth extracted without pain. 2.

In September, 1846, Morton, a former pupil of Wells's, aware of his discovery and repeating his experiments, extracted a tooth without pain, while the patient was under the influence of sulphuric ether. 3. In 1847 Simpson first introduced the practice of anæsthesia in midwifery, thereby making known more widely its value. He also discovered the anæsthetic properties of chloroform, and by his writings and teachings very largely contributed to introducing the practice of anæsthesia to the world. 4. Others have since discovered the anæsthetic properties of different vapors, which are more or less used in practice.

Loss of Self-Control in Battle.—In his "History of the Civil War in America," the Count de Paris gives some curious instances of the loss of self-possession among soldiers in the heat of battle. He states that, among 24,000 loaded muskets picked up at random on the Gettysburg battle-field, one-fourth only were properly loaded; 12,000 contained each a double charge, and the other fourth from three to ten charges. In some there were six balls to a single charge of powder; others contained six cartridges, one on top of the other, without having been opened. A few had twenty-three complete charges regularly inserted. Finally, in the barrel of a single musket there were found, confusedly jumbled together, twenty-two balls and sixty-two buckshot, with a proportionate quantity of powder! "But we should not severly criticise the American soldier," adds the author, "for it appears that an examination of the battle-fields of the Crimea gave similar results."

Pennsylvania Coal-Supply.—The available coal of the Alleghany coal-field is estimated by Mr. Andrew Roy, in the *Engineering and Mining Journal*, at 743,424,000,000 tons, an amount nearly ten times greater than the estimates made by Edward Hull and Warrington Smith of the coal resources of the British Isles. The same writer states the aggregate thickness of workable coal in the anthracite regions of Pennsylvania as 200 feet in 2,175 feet of coal-measures. In the bituminous regions of Pennsylvania, near Pittsburg, he estimates 60 or 70 feet of workable coal to 2,000 feet of coal-measures. In West Virginia, where the Kanawha River cuts the coal-measures to their base, 78 feet thickness of coal in 16 seams is revealed; and along the Ohio, from Bellaire to Pomeroy, the proportion is 40 or 50 feet of coal in 1,200 to 1,400 of rock. The number of workable seams and consequent thickness of coal in every division of the coal-area are in proportion to the thickness of the carboniferous rocks. Beginning at the base of the coal-measures, and reaching up to the height of 400 feet, to the base of the barren measures, there exist, in the bituminous regions, 3 feet of coal for every 50 feet of strata. The next 400 feet are generally barren of workable coal; but from the Pittsburg seam, which is the lowest bed of the upper series, to the outcrops or top of the coal-strata, the same general estimate of 3 feet of workable coal to every 50 feet of rock will hold good.

The People of Eastern New Guinea.—Signor d'Albertis agrees with Moresby in describing the inhabitants of Eastern New Guinea as of materially different race from the true Papuans, who are found in the far west of the island. The people of Yule Island, and of the coasts east and west of it, resemble those of the Polynesian region in many respects. The indigenous Papuans, physically and morally inferior to these Polynesian invaders, have been driven from the coast, where the land is comparatively healthy and fertile, and have permitted the intruders to establish themselves and multiply. The inhabitants of the interior are darker in color, the hair is more frizzed, and there is a difference in the form of the face, the prognathous appearance being more common than on the coast. From what D'Albertis has seen of the interior, he concludes that the land is very suitable for colonization, being well watered, with abundance of grass, and having a good climate without excessive heat. The natives are described as "intelligent, industrious, and persevering."

Body Temperature of the Drunkard.—Observations made by Dr. Reincke, of Hamburg, on eighteen drunken men, leave no doubt as to the great reduction of tempera-

ture in such persons, when the external conditions favor the withdrawal of the bodily heat. Alcohol produces a dilatation of the peripheral vessels, whereby more blood enters the skin and contributes to raise its temperature. If the body be well clothed and protected from external influences likely to abstract heat, the reduction of its warmth is inconsiderable; but if exposed to cold and placed under circumstances favorable to the abstraction of heat, there is a rapid loss of warmth from the blood circulating in the skin. The lowest temperature met with by Reincke—lower than in any recorded instance in which the individual survived—was the case of a man thirty-four years old, picked up in the street about midnight in February, when the temperature of the air was 30° Fahr. He was in a state of complete alcoholic coma, responding to no stimulant. At 8 A. M. his temperature, *in recto*, was only 75°, but at 12 M. it reached nearly 82°. At this period reaction began to show itself, and he could mutter a few words. From this point the heat of the body gradually increased and had reached the normal point the following morning.

Houses for the Industrious Poor.—The problem of cheap and commodious housing for the worthy poor continues to occupy the attention of philanthropists. We have already made mention in these columns of the bequest made by the late George Peabody for the erection of improved tenement-houses for the industrious poor of London. The trustees of the Peabody fund have recently completed twelve of these buildings, capable of accommodating 1,000 persons. In each building there are twenty-two tenements, consisting of one, two, or three rooms, with a separate entrance for each. The rooms are of good size, those of the three-roomed tenements being as follows: Kitchen, fifteen by twelve feet, a bedroom, sixteen by fourteen feet, second bedroom, sixteen by twelve feet, the rent being 5*s.* 9*d.* per week. The rent of a two-roomed tenement is 4*s.* 6*d.*, and for one room 3*s.* There are several cupboards and a meat-safe inside, and a coal-bin in the passage outside. On each flat is a laundry with every convenience; this is used by the tenants in turn. There is also a bath. The rules to be observed by the tenants are but few in number, and intended merely to secure cleanliness and good order. No one is allowed to occupy these buildings who earns more than thirty shillings per week.

Present Condition of the Suez Canal.—M. de Lesseps, on his return to Paris, after a five months' visit to Suez, communicated to the Académie des Sciences the details of his observations upon the present state of the isthmian canal. Port Saïd he found to be in no danger at all of being filled up with sand. The dredging-machine suffices to keep the channel clear. Moreover, it does not fill up so rapidly as has been supposed, for the work done last year still remains, and two very large ships have recently navigated the canal without difficulty—one of them drawing over twenty feet of water. In winter the current of the canal sets in toward the Mediterranean, owing to the excess of water in the Bitter Lakes; in summer the current is in the opposite direction. Since the construction of the canal there are frequent showers on the Red Sea, whereas, previously, rain was unknown there—a very extraordinary thing indeed, if it can be shown to be a fact. This rainfall, says M. de Lesseps, has started vegetation even on the Asiatic shore of the Red Sea, where the infiltration is only of salt-water.

Prehistoric Relics at the Centennial Exposition.—Mr. Ernest Ingersoll, natural history editor of *Forest and Stream*, has commenced in that journal a series of letters on the Philadelphia Exhibition. In his first letter he describes the collections of American prehistoric relics exhibited by the Smithsonian Institution and by various States, especially Ohio. For the purposes of general illustration, the Smithsonian collection he pronounces the best; but the State collections possess greater interest for the archæologist, as embracing many unique objects, only casts of some of which are to be found in the Smithsonian display. In the Ohio collection, the first object which attracts attention is an immense axe of greenstone, sixteen and a half inches long. The arrow-heads and spear-points—chiefly of

chalcedony—are remarkably fine. A few of these are made of obsidian, which must have been brought from Mexico. Articles of mica are there also, which must have been imported from a distance. The ornaments of the mound-builders are well represented, and include a variety of forms, all cut out of a blue Silurian slate-rock. Pipes of both the modern Indians and of the mound-builders are shown, the latter always carved in the form of some animal. One case contains a lot of awls, needles, and arrow-points, of bone and bear's teeth, upon which rude carvings are executed. There are also several human skulls in good condition. There are numerous photographs and maps of the enormous structures erected by the mound-builders throughout the Ohio Valley and northward.

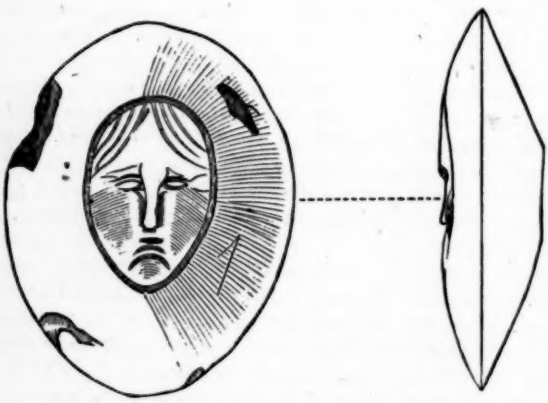
Winter Fauna of Mount Marcy.—While engaged last winter on the survey of the Adirondack region, Mr. Verplanck Colvin made some observations upon the winter fauna of Mount Marcy, and has since read a paper on that subject before the Albany Institute. Among the most important of the animals whose footprints were found in the snow was the panther (*Felis concolor*). Rabbit-tracks which accompanied the panther's trail indicated that the "mountain lion" had been in pursuit of small game. Next in importance to the panther in the list of species, the trails of which were observed, was the Canada lynx; this animal, too, had been rabbit-hunting. The footprints of the black cat (*Mustela Canadensis*) were frequently met with, associated with the tracks of rabbits and even of mice. The sable (*Mustela martes*) is abundant in the forests on the sides of Mount Marcy. Tracks of the ermine (*Putorius noveboracensis*) were recognized in one place, but the animal does not seem to be common. The rabbit, or, more properly, the white or varying hare (*Lepus americanus*), is so abundant as to bear the inroads of its many foes without apparent diminution. The common red squirrel (*Sciurus hudsonius*) was found at an altitude of about 4,000 feet; it feeds here on the seeds of the black spruce. On the slopes of the mountain, at all elevations not exceeding 4,000 feet, were seen the tracks of deer-mice, and occasionally the minuter trail of a small shrew. Of birds three varieties had left their footprints in the snow—the raven, the ruffled grouse, and the snow-bird. During a thaw in October a small moth was captured on the summit of the mountain; it has been recognized as belonging to a species abundant in Alaska. During the same thaw a beetle was found upon the very summit of the peak.

Eucalypti as Timber-Trees.—There are in Australia a number of species of gum-trees, or *Eucalypti*, the best known being the *Eucalyptus globulus*, or blue gum. As timber-trees their properties differ widely. The tewart, a variety of the white gum-tree, is of straight growth and noble dimensions. The wood is yellowish, hard, heavy, and strong, with a grain so twisted and curled that it is difficult to cleave or work it. This wood is very durable. The wood of the jarrah (*Eucalyptus marginata*) is much used for telegraph-posts and railroad-ties. It defies the white ant and teredo, and is practically unaffected by time, weather, or water. The kari (*Eucalyptus diversicolor*) is a magnificent tree, but the timber is subject to "star-shake." The iron-bark (*Eucalyptus resinifera*) produces timber that is very hard, heavy, and strong. It is very difficult to work. The wood of the blue gum is of a pale straw-color, hard, heavy, but only moderately strong. It is a durable wood, but its value is much discounted by its tendency to split. The stringy-bark (*Eucalyptus gigantea*) is a lofty tree; the wood is brown, hard, heavy, and strong. It is used for all kinds of work.

Concrete Construction.—One of the most interesting features of last year's International Exhibition, at London, was the show of buildings of concrete in course of erection. One exhibitor showed a building, the material of which was concrete, faced with tile and terra-cotta mouldings. In this case the tiles are arranged in a supporting frame in their proper position, and concrete is then filled in behind. The cost is stated to be about the same as the best brickwork. As regards the strength of concrete constructions, Mr. W. C. Homersham, C. E., states that the staging necessary for carrying a

concrete floor, in the green or wet state, of a room say twelve and a half by twenty-five feet, may be struck in a week after the completion of the floor, if the concrete be only six inches in uniform thickness, and gauged in such proportions that every cubic yard when *in situ* contains four bushels of Portland cement, and six bushels of clean, sharp, siliceous sand. One month after the concrete has set, the floor would be capable of sustaining an equally-distributed load of 112 pounds to the foot superficial, and, twelve months after, an equally-distributed load of 450 pounds per foot superficial. If the thickness of the flooring be increased to twelve inches, and the concrete gauged as before, a room nineteen and a half feet in width by any length may be covered with the same results as to strength, as those given above for the room twelve and a half feet in width. A wall of concrete is impervious to water, and fire-proof.

A Relic of the Mound-Builders.—Through the kindness of Prof. A. E. Dolbear, of Tufts College, Massachusetts, I am enabled to present to the attention of archæologists a brief notice and figure of an unusually interesting specimen of carving in stone, the work of the



mound-builders of Ohio. The history of the specimen, as given me by Prof. Dolbear, is briefly this: "It was ploughed up in a field a few miles from Marysville, Union County, Ohio."

The relic is a small pebble of bluish-gray slate, highly polished, and ground to a moderately sharp edge. The front or carved side is oval and of a uniform surface; the back is sloped from a central flat, oval space, about one-fourth of an inch in its long diameter. Had the specimen not the carving of a face upon it, it could properly be classed with that form of implement known as the "celt," although these very seldom have an edge extending along the entire margin. Circular celts or "skinning-knives," of about the same size, with a cutting-edge along the whole margin, have been found by the writer, in New Jersey.

The remarkable feature of the relic here described is the human face carved upon one side. As a representation of a woman's face, it is certainly artistically executed. As has been remarked of a mound-builder's smoking-pipe, having a somewhat similar carving,[1] "the muscles of the face are faithfully rendered, and the forehead is finely moulded. The eyes are prominent and the chin open, and full and rounded." The nose and mouth are distinctly cut, but not as accurately finished as the other features.

Although the labor expended upon the stone to bring it to so well defined an edge, about its margins, was so considerable, the specimen can scarcely be considered an ornamented cutting-implement. Celts, such as we have referred to, are never marked by carvings, even of plain lines, so far as we have collected them in New Jersey; although some other forms, as plummets (?) and pestles, were occasionally carved. What, indeed, this relic really was, when the aborigine who carved it had it in possession, it is useless to conjecture. Its value now consists in its being a well-preserved specimen of the work of a stone-age savage; and possibly a characteristic delineation of the features of a woman of the race known as the mound-builders.

CHARLES C. ABBOTT, M. D.

The Loan Exhibition in London.—The exhibition of scientific instruments at London was opened with an address by Mr. W.

[1] "Flint Chips," p. 433, American edition.

Spottiswoode, F. R. S., who, after calling attention to the great number of antique instruments present, dwelt upon the valuable services often rendered to science by earnest students possessed of very inadequate means. "In reviewing," he said, "the series of ancient, or, at least, now disused instruments, one thing can hardly fail to strike the attention of those who are accustomed to the use of the modern forms. It is this: how much our predecessors managed to achieve with the limited means at their disposal. If we compare the magnificent telescopes, the exquisite clock-work, the multiplicity of optical appliances now to be found in almost every private, and still more in every public observatory, with those of two centuries past; or, again, if we look at the instruments with which Arago and Brewster made their magnificent discoveries in polarized light, in contrast to those with which the adjoining room is literally teeming, we may well pause to reflect how much of their discoveries was due to the men themselves, and how comparatively little to the instruments at their command.

"And yet we must not measure either the men or their results by this standard alone. The character of the problems which Nature propounds varies greatly from time to time. First we have some great striking question, the very conception and statement of which demand the highest powers of the human mind. Next follow the first outlines of the solution sketched by some master-hand; afterward the careful and often tedious working out of the details of the problem, the numerical evaluation of the constants involved, and the reduction of all the quantities to strict measurement. It is in this part of the business that the more elaborate instruments are specially required. It is for bringing small differences to actual measurement that the complex refinements with which we are here surrounded become of the first importance. But happily this complication is not of perennial growth. In reviewing from time to time the various aspects of a problem in connection with the instrumental appliances designed for its solution, the essential features come out by degrees more strongly in relief. One by one the unimportant parts are cast aside, and the apparatus becomes reduced to its essential elements."

NOTES.

THE Franklin Institute of the State of Pennsylvania has opened a reception-room at the northwest end of the Machinery Hall, Centennial Exhibition grounds. The following objects of great historical interest have been placed in the room: 1. Franklin's electrical machine; 2. Oliver Evans's steam locomotive-engine, constructed in 1804; 3. Oliver Evans's high-pressure steam-engine, same date; 4. Working model of a steam-engine constructed by M. W. Baldwin, presented by him to the Franklin Institute, about the year 1832. Files of the industrial journals may be found here, and visitors will be cordially welcomed.

PRELIMINARY steps have been taken for holding an international horticultural exhibition and botanical congress in London in the year 1879.

A REPORT made to the Silk-Merchants' Union of Lyons states the silk-crop of Europe in 1874 to have been, in round numbers, 9,050,000 pounds. The silk imported into Europe amounted to 11,500,000 pounds, most of it (8,000,000 pounds) coming from China. The greater part (6,000,000 pounds) of the domestic silk was produced in Italy.

A COURSE in Herbert Spencer's "Principles of Psychology" will be given at Harvard University during the year 1876–'77, under the instruction of Prof. James.

IN the *Pacific Medical and Surgical Journal* a case is recorded of the conveyance of small-pox in a letter from Indiana to California. A man in the latter State received last December a letter from a sister in Indiana, stating that four members of her family had small-pox. A few days after the receipt of the letter, the man became ill, and the disease developed into a well-marked case of discrete variola.

IN the sugar-plantations of Natal the large python is employed to keep down rats and mice.

AT a late meeting of the St. Louis Academy of Science, Prof. C. V. Riley exhibited cocoons and spinning worms of the common mulberry silk-worm (*Sericaria mori*) reared on Osage Orange. The worms were a cross between the best French and Japanese races, and he had reared them for five years on Osage Orange with no reduction in quantity or quality of silk, and great increase of vigor and healthfulness.

MACMILLAN will publish in the fall two volumes by Prof. Wyville Thomson, on the "Results of the Challenger Expedition." This work will be illustrated by drawings, made on the spot by Mr. Wild, the artist of the expedition, of the many curious and beautiful creatures now for the first time brought to light.

A NEW grape-fungus, which first appears on the leaves of the grape-vine, in the form of a minute yellow spot, was described by Dr. Engelmann, at a recent meeting of the St. Louis Academy of Science. It makes its appearance just before and during the flowering period, as far as known attacking only the leaves, or rarely the petioles and peduncles. It kills the leaves, and thus cripples the plant, and attacks all varieties indiscriminately.

A SET of wheels was lately taken from beneath the baggage-car of the California and Oregon express train at Sacramento, which had traveled in daily use 91,800 miles, nor were they worn out even then, but had become loose on the axle.

THE Challenger Expedition returned to England May 23d, after an absence of three years and five months. During that time the vessel sailed 61,840 miles. The number of soundings made was 370, of dredgings, 360. Some hundreds of specimens were sent home during the voyage. The mortality was not above the mean, and, when it is remembered that the average time at sea was 220 days per year, it is surprising that the health of those on board (259 in number) was as good as it was.

DURING the thirty years, 1841–'70, the death-rate of England and Wales was nearly stationary, about twenty-two per thousand. It must not be supposed, however, that in the mean time no progress was made in sanitary science. The rapid development of manufactures led to the crowding of people in towns, and this must have tended to produce a higher death-rate. The local statistics strikingly exhibit the influence of this massing of people in manufacturing and mining centres. For instance, while Cambridgeshire shows a progressive decline of death-rate, in the West Riding of Yorkshire, where the urban population has been enormously increased, the death-rate has been steadily rising.

A STREET-PAVEMENT of pig-iron is soon to be tried in Paris. In constructing a roadway of this kind, a bed of mortar is first laid down, which is covered by a strong layer of asphalt; it is in this layer that the iron cakes, which are about 1.6 inch thick, are set. These cakes, it appears, preserve the homogeneity of the bitumen and prevent its depression, and render the asphalt less slippery for horses. This pavement will cost more than the compressed asphalt, but it is estimated that it will save 50 per cent. of the repairing expenses, which are very considerable. The end desired is to avoid, by the adoption of this kind of pavement, the depressions in roads over which a great deal of traffic passes. To attain this, it does not suffice to pour bitumen upon a well-prepared ground lightly covered with a coat of lime; the resistance of the ground should equal that of an old macadamized bank; and a very thick bed of mortar, which should be very homogeneous, should be laid before the asphalt.

A NEW process of gas-manufacture has been patented by Malam, manager of the Dumfries (Scotland) Gas-Works. The advantage claimed by the inventor for the new process is, that a large proportion of the liquid hydrocarbons, which would otherwise go to form tar, are converted into gas, and thus an increased production of gas is insured to the amount of 3,000 or 4,000 feet per ton, while the quality is not deteriorated.

IN announcing the sale of the Hoosac Tunnel machinery, the *Engineering and Mining Journal* remarks: "The contractors completed, in the most satisfactory manner and it is said at a considerable pecuniary sacrifice, a most difficult work (the tunnel), and one which is of considerable advantage to the State (Massachusetts), and it is greatly to be regretted that the government of a great State should resort to those devices, to avoid the fair and honest performance of their engagements, which, when practised by individuals, are characterized as 'tricky' and 'dishonorable.'"

WATER which has been kept for some time in the state of ebullition does not make so good an infusion of tea as water "just upon the boil." A reason for this is suggested by a writer in the *Chemical News*, who says that the escape of dissolved gases might possibly account for the inferiority of tea-infusion made with long-boiled water. To test this, he passed for ten minutes through boiling water a stream of carbonic-acid gas, and then made an infusion of tea with it. The result was decidedly better than when water was employed that had boiled for the same length of time without the addition of the CO_2.

THE depth of the Pacific Ocean between Hawaii and Tahiti, as developed by the soundings of the Challenger Expedition, ranges from 2,000 to 3,000 fathoms, with one exception of 1,525 fathoms. The bottom, except near the islands, is mainly red clay, with much oxide of manganese in small concretions and many foraminifers.

WILLIAM BARTON ROGERS.